STATE OF MICHIGAN

DEPARTMENT OF NATURAL RESOURCES

LANSING

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August 23, 2012

Mr. James Sallee
Michigan Department of Environmental Quality
Water Resources Division
Jackson District Office
301 E. Louis Glick Highway
Jackson, Michigan 49201-1535

Re: Fisheries comments concerning DEQ file no. 12-81-0027-P

Dear Mr. Sallee:

The Michigan Department of Natural Resources (DNR), Fisheries Division is providing comment on the Michigan Department of Environmental Quality (DEQ) permit application titled "MichCon Broadway Street MGP Whitewater and Habitat Improvements" (DEQ file no. 12-81-0077-P). The DNR met on two separate occasions with representatives from DEQ, City of Ann Arbor, TRC and Recreational Engineering and Planning (REP) to discuss the proposed project.

At those meetings, DNR expressed issues of concern relative to the two channel-spanning whitewater structures proposed to be constructed in the main channel of the Huron River downstream of the Argo Dam. Specifically, that the proposed structures were in fact dams created with a U drop that creates a hydraulic roller and allows for kayak passage. The DNR provided the Dams and Barriers Policy 01.02.002 to the participants (Attachment 1). The policy clearly states that, "Because of the significant environmental effects of dams, Fish Division does not support new dam construction." The policy outlines and provides citations of the effects that dam have on riverine ecosystems.

Much discussion at the meetings focused on DNR's position that any structures proposed must allow for unimpeded fish passage for all species, at all times of the year, for all life stages relative to what exists with current conditions. During the initial meeting with the applicant, DNR expressed the need to incorporate unimpeded fish passage into any proposed structure. Discussion ensued why fish passage would be necessary since Argo Dam was located upstream of the proposed project. In Michigan, and around the county, dam removals are becoming more prevalent due to aging infrastructure requiring costly repairs. If the dam still serves an economic purpose, private investments would be made to maintain and repair them. A decision to "leave the dams alone" is a decision to promote deterioration and invite uncontrolled consequences to both human and natural communities.

The American Society of Civil Engineers considers dams to have an engineered life span of 50 years. In most cases, state and federal funding have been used to address water- quality issues associated with dam failures and restoration because dam owners do not have the funding necessary to either maintain or remove the dams. <u>Any new structures constructed in a river system should allow for fish passage and natural sediment transport so as not to repeat the history that we are currently funding and living.</u> Dams are not permanent structures and in this case the location of Argo Dam in relation to the proposed structures should not allow for further degradation of the Huron River. Planning should provide for a naturally functioning system below Argo Dam as history has made clear that, at some point in time, the Argo Dam will be modified or removed. Impediments should not be constructed in the river that the public will again be asked to address.

Additionally, discussion focused on the need for natural stream function and that sediment transport should remain unchanged with the construction of any structure. Sediment transport is necessary to maintain the stability of the stream so that it maintains its dimension, pattern and profile and neither aggrades nor degrades, thereby maintaining current habitat in the stream. This is true for any river, but specifically it is important for this site so as not to compromise the remediation conducted on the adjacent contaminated MichCon site.

Following the meeting, DNR sent an e-mail from Chris Freiburger to REP on March 7, 2012 which is included as Appendix 7 in the permit application (Attachment 2). The e-mail was provided at the request of Mr. Gary Lacy, REP, to provide clarity and reiterate many of the issues discussed at the previous meetings and offered additional information sources that may assist in design modifications.

In the "Alternatives" section the applicant offered modifications to the initial design in an attempt to enhance fish passage and sediment transport by reducing slope between the crest and pool structures, the addition of roughness and a vertical-slot fish way. The applicant offered these design modifications as alternatives and suggests that any other changes to reduce slope will degrade the whitewater features to a point that their benefit as recreational features would be minimal.

DNR does not view modifications to the initial design as alternatives to the proposed project, but as a necessity to maintain current conditions without degradation. Also we do not support the applicant's position that further changes to the structure would provide minimal recreational benefit. Our experience here in Michigan has been that the development of natural channel-design structures that provide for unimpeded fish passage and sediment transports have also provide many recreational opportunities including kayaking, canoeing, tubing, angling, boating, swimming and viewing.

The State of Minnesota has had similar experiences with whitewater enthusiasts utilizing natural channel design structures and often incorporates rounded rock into their designs as not to damage watercraft with sharp rocks and reduce injury to recreationalists. Aadland (2010) has found that emulating natural channel geomorphology and materials has several advantages. First, fish react to complex current and bathymetry cues, and channels similar to natural channels are less likely to cause disorientation than channels that are not. Second, natural channel design allows fish ways to provide important habitat as well as passage. A greater number of alternative spawning areas are also likely to provide greater reproductive success and resilience. Third, use of natural substrates, rather than concrete or other smooth materials, provides roughness and interstitial spaces that allow small fishes and benthic invertebrates to pass and, in many cases, colonize.

The March 7 e-mail clarifies that the applicant should follow the Natural Channel Design (NCD) checklist provided by DEQ as a guidance document. This information must be collected to fully evaluate the proposed stream project. Specifically, the e-mail responds to the applicant's question of what sediment model should be utilized to determine if the proposed structures will have any effect on sediment transport that differs from that which currently exists. The DNR e-mail responds that, "As it relates to sediment model selection the NCD checklist recommends the applicant select a model and discuss its appropriateness with the regulatory and resource agencies." Unfortunately, there was no follow up by the applicant to discuss with DNR appropriate models to use for sediment transport.

Additionally the e-mail states, "I also wanted to note that, as the NCD checklist addresses, when additional geomorphic information is collected (i.e. longitudinal profile) it is necessary to collect bank full measurements on all cross sections and the longitudinal profile in order for DNR to evaluate. My understanding is that to date no longitudinal profile or bank full measurements have been taken on any of the data which has been collected. Further reference reach information may need to be collected to determine stable conditions in order to determine appropriate design if the subject reach is deemed to be unstable based on geomorphic data collected."

Unfortunately, detailed geomorphic information was not collected in the stream reach as requested both by DNR and DEQ staff in the meetings or in the follow up e-mail from DNR. Although numerous cross sections were provided, by the applicant, presumably for HEC-RAS model runs, they do not provide the level of detail for a geomorphic survey or describe what facets the cross sections traverse (i.e. riffle, run, pool, and glide). Further, based on review of the application, it does not appear that a detailed longitudinal profile in the thalweg was surveyed which is needed to determine reach, facet, bank full, bed slope and other geomorphic data.

Neither the cross sections nor longitudinal profile identify bank full elevation which is paramount to understanding what effect structures will have on a stream. This is unfortunate since it was clearly articulated that bank full measurements are necessary. The NCD checklist also indicates that pebble counts should be conducted at cross sections, along the longitudinal profile and point bars.

The only indication in the application that refers to sediment characterization, which we were able to locate, was found in Table 4 of the Hydraulic Report and Model in Attachment 8 in the permit application. The information provided indicates that TRC Environmental conducted a grain size analysis at site T-4-3 and the D_{90} was 250 millimeter (mm). No additional information was provided on the location or method of sample collection. Pebble count information is necessary for classification purposes, discharge, and sediment transport calculations (competence and capacity).

As a result of not having sufficient detailed geomorphic data, as discussed and requested, it is difficult for the applicant and the DNR to fully evaluate the effects of the proposed project on natural stream function and aquatic organism passage on the this stretch of the Huron River. In order to evaluate, staff from DNR and DEQ dedicated substantial time collecting and analyzing geomorphic data to determine stream impacts and validate model input parameters from tables and assumed values relative to actual geomorphic data collected.

Please find DNR comments below to specific sections of the permit application. For organization and efficiency of review, page numbers and excerpts contained within the application are copied below in standard formatting. The DNR response follows in italics.

Fill/Excavation Summary

Attachment 5, Fill/Excavation Summary, states that, "The project has proposed to excavate a total of 728 cubic yards of sediment in the Huron River in an area of 9,776 square feet (ft). In addition, the project proposed to place a total of 1,783 cubic yards of fill overt a 23,263-square-foot-area. The net effect of the excavation and fill is a 1,055 cubic yards gain in material (less floodplain storage). This loss in floodplain storage will be offset by the gain on 1,555 cubic yards in storage to be made by the concurrent proposed remediation of the Former Broadway

MGP site on the southern bank of the Huron River (File No. 11-81-0066-P). When considering both projects, a small net gain in floodplain storage will be achieved."

Based on information provided by the applicant a small increase in floodplain storage will be recognized immediately in the proposed project area while 1,554 cubic yards of fill are being placed below the ordinary high water mark and bank full elevation. The increase in storage capacity is important as it relates to water surface elevations. However, a large quantity of fill is being placed in the bank full channel inducing immediate changes in bank full cross sectional area, slopes, depths and roughness.

Comments below are specific to the document titled; "Summary Hydraulic Report and Final Design for the In-River Whitewater Structures-Huron River, Ann Arbor, Michigan" dated April 19, 2012 and is included as Attachment 8 in the application.

Model Parameters

Page 7. REP created the proposed conditions model using the existing conditions model as a base while inserting proposed geometry at specific locations to mimic the proposed modifications. Using the existing conditions model as a base allows for direct comparison between the existing conditions and the proposed conditions. This is referred to as "apples-to-apples" comparisons within this report.

DNR concurs that inserting proposed geometry at specific locations to mimic the proposed modifications at the physical location of the structures is acceptable to have an "apples to apples comparison". However many parameters in the model run need to be modified for hydraulic evaluation since geometry of the cross section will change including roughness, cross sectional area, depth and slope.

Page 8. The Manning's "n" value used for the proposed conditions channel varied from 0.02 to 0.03 depending on location. Values of 0.02 were used at the crest and exit of proposed drop structures to reflect the roughness of smoothed concrete drops (Chow, 1959, Barnes, 1987) and values of 0.03 were used at locations with no change from the existing conditions model. Overbank values were unchanged from the existing conditions model and ranged from 0.04 to 0.1.

The applicant uses a Manning's n value of 0.02 as the roughness coefficient at the crest and exit of the proposed drop structures. It is not clear from the application what type of channel and description the applicant used from Chow's table (1959), however DNR does not concur with the roughness coefficient used by the applicant. Chow (1959) shows Manning's n values for Lined or Channel, neat cement (5, a, 1) ranging from 0.010 to 0.013 with a normal 0.011 while mortar (5, a, 2) has a range of values from 0.011 to 0.015 with a normal of 0.013 (Attachment 3).

Further, the Huron River Watershed Council collected flow data at structure number six in the Argo headrace. Flow measurements were taken mid-way through the structure. This location was chosen so measurements were not influenced by backwater created at the crest or turbulence at the exit of the structure. Based on the discharge data collected Manning's n was back-calculated having a value 0.01 which is consistent with Chow's values described above. The decrease in Manning's n values and roughness will result in increases in mean velocity predictions.

Page 9. The upstream boundary condition of normal depth was also used and multiple thalweg elevations were used to determine the appropriate slopes. The slope was found to be relatively inelastic and all values were set to a slope of 0.0015.

Staff from DNR and DEQ conducted a detailed longitudinal profile which included the project reach which extended from the riffle immediately downstream of Argo Dam to the first riffle downstream of the proposed project. The longitudinal profile begins and ends on a riffle since they are the same facet features and serve as hydraulic controls in the river dependent on flows. Riffle to riffle bed slope through this area was measured at 0.0033 ft/ft or 0.33% (Attachment 4).

Page 9. The model was run under subcritical flow conditions for existing conditions and proposed conditions to reflect the existing hydraulic conditions within the modeled reach. Cross sections within the drop structures, and the associated hydraulic jump, are not effectively modeled by HEC-RAS. Because of this, "errors, warnings, and notes" in these areas were disregarded.

Not surprisingly, error messages would be expected when conducting modeling runs with HEC-RAS within the drop structures since they are not effectively modeled by running sub-critical flow conditions in HEC-RAS. The errors and warnings provided by the model should not be disregarded as they are provided to the user to indicate it is outside of the bounds of model. HEC-RAS is a one dimensional model that was not developed to handle complex hydraulics as experienced at these structures. HEC-RAS does allow the user to run a mixed flow scenario, however from the indications in the narrative this feature was not utilized. Even with the use of the mixed flow model run HEC-RAS is a one dimensional model that does not predict velocity distributions through a complex structure.

Fish Passage

Page 15. To model and design the fish passages, REP took the HEC-RAS model explained above and isolated the areas designed for fish migration. While the one-dimensional model has specific limits and capabilities, it provides quantifiable hydraulic calculations that can be used when assessing mean velocities in areas designed for fish migration. HEC-RAS is the industry standard for water surface, and associated depth, hydraulic calculations.

DNR concurs with the applicant that the one dimensional model, HEC-RAS, has specific limitations and capabilities and it does provide quantifiable hydraulic calculations used to assess mean column velocity. HEC-RAS may be used to provide "rough" estimates of velocity however it should not be used to calculate velocities for final fish passage design purposes. Further, mean water column velocities are an inappropriate parameter to utilize to predict fish passage. The actual velocities and velocity distribution are useful to assist in determining fish passage. Aadland (2010) stated, "This limits the usefulness of hydraulic models in predicting fish passage. While more sophisticated two- and three-dimensional models are available, like all models, they are only as accurate as the data input into them. Accurate depictions of bed velocity require detailed surveys of the streambed."

HEC-RAS does not account for this distribution. We recognize that FEMA and many state regulatory agencies utilize HEC-RAS to predict water surface elevations; however it is not the accepted standard for fisheries sciences as it relates to aquatic organism passage.

In July of 2012 the Huron River Watershed Council measured water depth and velocities at 20%, 40%, 60%, 80% and full depth at structure 2 in the Argo Headrace. Data results can be *seen below. Measured velocities at structure 2 varied through the water column particularly near the water surface. Velocities ranged from 2.92 ft per second (fps) to 6.03 fps through the water column.*

Depth profile at Chute 2 (first one past the chute 1/bridge/weir)

	Depth	Velocity (ft/s)			
			Mean velocity	5.136	fps
20%	0.2	2.92	80/20 velocity	4.42	fps
40%	0.4	5.12	60 velocity	5.69	fps
60%	0.7	5.69			
80%	0.9	5.92			
100% (full depth)	1.1	6.03			

Page 17. To model the preferred design, REP staff installed approximately 0.6 foot high by 0.6 foot wide obstructions within the fish passages. The obstructions were put at varying elevations, thicknesses and locations as shown in Appendix 6. The obstructions were designed to effectively model the protruding boulders that will be placed within the roughened fish passages. In addition, the Manning's n-value was raised to 0.06 to accurately reflect the roughness that is estimated within these passages. For reference, USGS Water Supply Paper 1849 contains a visual reference (See Figure 6) for the aforementioned Manning's n-value.

As the applicant has explained HEC-RAS has the capability of calculating one-dimensional mean column velocities (among other statistics) for up to 43 vertical subsections (slices) of the conveyance area, and associated depths. These statistics provide valuable information that can be used during design and the associated optimization.

As discussed above HEC-RAS is a not able to predict velocity distribution and therefore is not an appropriate tool for determining fish passage. Further, we would contend that just because a model has the capability to provide up to 43 vertical subdivisions does not indicate that they should be used or more importantly that the model outputs are accurate.

Obstructions 0.6 ft wide and high were incorporated into the three-foot wide vertical slot fish way to simulate protruding boulders proposed to be grouted into the fish way. As depicted in Appendix 6 of the application, the three-foot vertical slot fish way was subdivided into approximately 0.5 foot sections to simulate the effect of obstructions on mean water column velocities. Modeling these subdivisions implies that there are discrete rigid boundary conditions that begin and end at the edge of each of these obstructions and continue through the water column.

Clearly, discrete boundary conditions do no exists as the model predicts. Flow over and through the U drop and vertical slot fish way is not entirely laminar due to the substantial reduction in bank full cross- sectional area resulting in increased head, flow convergence and turbulence. The model runs used to predict mean column velocities depict a discrete boundary between the U drop and the vertical slot in the vertical slot fish way which does not exists. As the applicant clarifies the model does not account for the effects of turbulence, velocity vector orientation and vertical turbulence. So although the model may allow the user to subdivide the cross section it must be used appropriately and results interpreted cautiously.

Not unlike the Manning's n-value that was chosen by the applicant for the U drop of the structure, DNR does not concur with a Manning's n-value of 0.06 to reflect the roughness of the fish passageway. The applicant cites the use of Water Supply Paper 1849 in determining the appropriate n value. The Water Supply Paper 1849 is titled, "Roughness Characteristics of Natural Channels." It provides a tool to assist practitioners in selecting the appropriate Manning's n-values. In the introduction it states that, "Familiarity with the geometry, appearance, and roughness characteristics of these channels will improve the engineer's ability to select roughness coefficients for other channels."

According to Chow (1959) which DNR and the applicant referenced, the fish way channel may best be described in Chow's table as Lined or Constructed Channel, random stone in mortar (5,d,2) with a range of Manning's n-values of 0.017 to 0.024 with a normal of 0.02. Even for channels described as Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages, bottom, gravels, cobbles and few boulders (2,a) has a range of 0.03 to 0.05 with a normal of 0.040. This last description would more accurately reflect the existing Huron River channel prior to the proposed modification.

In fact, Manning's n was solved for at the bank full stage at the surveyed riffle cross section then using friction factor and relative roughness the Manning's n roughness coefficient was calculated at 0.033 with a discharge of 1504.23 cfs. The discharge depicted on the USGS stage rating table has a discharge related to bank full stage of 1521 cfs. There was very good agreement between the two methods. Further, the Manning's n value for the Rosgen F4 stream type (Rosgen 2009) has a Manning's n value of 0.33.

Further, the vertical-slot fish way with the roughened channel is not accurately represented by this paper as the fish way is not a natural channel in geometry or material. The roughened bottom consist of cobble, small boulders and grout which make up the bed at this location both of which may substantially lower the Manning's n-value below 0.06.

The vertical slot fish way as proposed will have cobble veneer with small hand placed boulders protruding up to 0.6 ft above the grouted surface to induce roughness. The increased roughness relative to smooth concrete may reduce velocities at some level however it should be recognized that spaces between the cobble and small boulders will be smooth grout with much lower Manning's n-values. There will be little to no overlap of cobble or boulders and the bed will be homogenous with gaps composed of grout.

This is unlike a heterogeneous bed, which currently exists in the Huron River, with a mixture of silt, sand, gravel, cobble and boulders which overlap inducing rough boundary conditions. This differs from the proposed vertical slot fish way with grout, cobble and small boulders. Heterogeneous mixtures provide for a roughened channel bottom and allow fish and other aquatic organisms to move upstream along the stream bottom.

Aadland (2010) offered, "That most fish have burst speeds that approximate ten body lengths per second but they cannot maintain this speed for more than a fraction of a second to a few seconds. Small fishes have proportionately slower burst speeds but have the advantage of moving closer to or within the substrates where velocities are slower. Some small riffle oriented species like the rainbow darter (Etheostoma caeruleum) shown, prefer habitats where mean column velocities are greater than their burst speed capability. The use of interstitial space as a velocity refuge is not restricted to small fishes... Bed velocities are lower above large substrates due to the resistance they create. Velocity distributions near large substrates are also very complex resulting in small eddies that provide resting areas. The distribution of velocity is far more important than are mean column velocities... Concrete is smooth resulting *in less resistance and high bed velocities. It also lacks interstitial space important to the passage of small-bodied species."*

Page 18. The invert of the fish passage was designed to be 0.7 ft lower than the low flow portion of the structure on the upstream side. This design geometry ensures the fish passage is "wet" and contains water down to the lowest discharge during drought conditions. The fish passage will operate even when there is no in-stream recreational value in the structure and no water flowing over the low flow portion of the structure. Multiple parameters were set to facilitate fish migration. The slope of the fish passage was set at 30:1 to create hydraulic conditions that further reduce velocity. The 30:1 slope was chosen based on engineering experience, prior modeling results, existing modeling results, and associated studies (Kubitschek, et. al. 1997 and Kubitschek et. al. 2001). In addition, multiple cobbles and small boulders were placed to create off-setting sills (Kubitschek, et. al. 1997, Kubitschek et. al. 2001, Price Stubb Fish Passage Final Environmental Assessment. 2004). The sills create valuable velocity refuge zones and micro-eddies within the turbulent boundary layer (Schlicting, H. 1979) that has been shown to facilitate fish migration. Concrete and boulders placed within the passages are designed to maximize irregularities and increase the Manning's n-value to as high as 0.08-0.1. This ensures maximum friction within the fish passages, eddy features, velocity purposes, these areas are assumed to have a conservative aggregate Manning's n-value of 0.06. All of these design parameters facilitate fish migration.

At the initial meetings DNR provided comment and later provided e-mail and additional information on the best available information on fish passage, specifically on hydraulic head, step height and slope. The applicant states that they have modified the original structure design to enhance fish passage and sediment transport by reducing slopes between the crest and pool structures. A three-foot wide vertical-slot fish way was incorporated into the design that is 0.7 ft lower than the U drop portion of the structure on the upstream side and overall has a slope of 30:1 in the fish way. DNR appreciates the efforts to improve fish passage and incorporating a vertical-slot fish way with low slopes.

However, <u>DNR does not concur that a three-foot vertical slot fish way with a roughness element and a 30:1 slope will have similar fish passage capabilities as existing conditions.</u> Bank full cross sectional area will be reduced by 78% at structure 1 and 72% at structure 2. The intent of the structures are to pass flows from sub-critical to super-critical to create a hydraulic jump for kayakers. This is done by raising bed elevation (creating a dam and impounding water), reducing cross sectional area which results in convergence of flow thereby increasing water velocity, and shear stress over existing conditions.

Even with the modifications of the structures to enhance fish passage and sediment transport, the structures continue to have a substantial hydraulic head that dictates the hydraulics of the structure. Therefore the effects that the proposed modifications have on the structure will be minimal.

Information provided to the applicant from Verry (2011) and Aadland (personnel communication 2012) and addressed in our March 7 e-mail indicated that head loss should not be greater than 0.7 ft for effective fish passage. The proposed structures are approximately 19 ft in length, in an upstream and downstream direction at the U drop with a 1 foot drop in elevation from the crest to the exit of the structure with a slope greater than 5.0%

In July, Flow depths and water velocity data were collected by the Huron River Watershed Council at structures 2 thru 5 in the Argo Headrace. Data are depicted in the table below. Velocities were lower near the upstream end or crest of the structure and then increase *dramatically as the water travels through U drop and through the outlet of the structure. Huron River Watershed Council took depth and velocity readings approximately 1.5 ft upstream of the exit of the structure. Council staff had intended to take measurements at the downstream end of the structure although velocities were too high to safely stand at this location (Steen 2012, personal communication).*

Water velocity through chutes

	Depth (feet)			Water Velocity fps (@ 60% depth)		
	Top	Mid	Bottom	Top	Mid	Bottom
Structure 2	1.1	1.25	1.25	5.69	5.74	7.45
Structure 3	1.35	1	0.9	3.33	8.14	9.86
Structure 4	1.2	0.75	1.5	2.8	8.61	7.51
Structure 5	1.3	1.25	1	3.41	5.29	9.35

Most fish species inhabiting Michigan waters are not strong swimmers and are not able to sustain swim speeds of over three feet per second (fps) for any extended period of time. Typically, in low gradient Michigan streams, velocities of three fps are found during bank full events when many fish are found to move. Based on our experience in high slope streams of two percent or more flow velocities typically are near five fps at bank full flow. As can be seen from the values above, only one data point falls below the three fps even though flows are well below bank full. Based on the data and the information available on fish swim speeds, <u>these existing structures appear to serve as barriers as the velocities are greater than burst and sustained swim speeds for the majority of fish species inhabiting the Huron River.</u>

Based on the science produced by leading fish passage experts in the country and data collected at the existing structures of the Argo Headrace there is no expectation that the proposed structures, even with the modifications, will be any more effective at fish passage than those currently occupying the headrace. In fact, due to the proposed cross channel structures being designed for moderate and advance users, instead of novices as they are in the Argo Headrace, <u>there is an expectation that conditions for fish passage would be reduced.</u>

Page 19. Depth is a key parameter associated with fish habitat (McGrath, 2003). The proposed conditions will create two significant pools downstream of the structures. The pools are designed to not only dissipate energy associated with the drop structures, but also to create valuable holding areas for fish and deep over-winter habitat that protects aquatic habitat from predation. Specifically, the pools will be approximately 4 ft deep (at lower flows) just downstream of structures. REP staff has performed multiple snorkel surveys downstream of structures resulting in qualitative observations showing these areas are common feeding zones and holding areas.

The applicant is correct in that pools provide critical habitat for fish. This is true not only in the winter but during all seasons of the year. However, the Huron River from the upstream extent of the Barton Impoundment to Ypsilanti Dam is not limited by pool habitat. This stretch of river is approximately 14.7 miles in length with impoundments comprising 13 miles and free flowing river just 1.7 miles or approximately 11%. The proposed structures would substantially reduce the free flowing portion of the river by 2%. Riffle, glide, and run habitat are the limiting habitat *type in this stretch of the Huron River and every effort should be made to protect and restore these habitats not allowing reductions causing further habitat degradation.*

A detailed longitudinal profile 1,036 ft in length was surveyed from the Argo Dam to the outfall of the Argo Headrace. Riffle to riffle bed slope in this reach was 0.33% with a bank full slope of 0.25%. Measured riffle to riffle bed slope from the Argo Headrace outfall to the USGS Wall Street Gage (No.04174500), a distance of 3,061 ft had a slope of 0.053% or six times less than the comparative reach. Relative to other Michigan streams, and the Huron River itself, this stretch of river is regarded as high quality habitat not only because it is high gradient riffle/pool habitat but also it is not impounded has quality gravel substrate and considerable large woody habitat.

Work conducted by aquatic researcher Matt Kondratieff (personal communication 2012), Colorado Parks and Wildlife, specifically studied densities of brown trout in sections of a river system that had whitewater park structures installed vs. natural river channel. Based on electro-fishing results Kondratieff found brown trout densities (expressed a number per pool) in the scour pools below whitewater structures to be 53% of densities in the natural channel in the lower section of the river, 32% of densities in the natural channel in the middle reach and 9.3% of densities in the natural channel in the upper section.

Ongoing research is being conducted to understand why pools created by the U drop structures have lower densities than natural pools. There may be many reasons; however potentially it may be that that the environment is too extreme and the fish may have to expend too much energy to stay within the pool. This concept may be supported by the fact that the application calls for boulders in the pool bed below the structures to be grouted to hold them in place. The need to grout boulders together in the pool indicates tremendous shear stress and high velocities. If boulders and grout are needed to maintain the substrate in place, it speaks to the energy in the system and indicates that constructed pools do not act similarly to pools in streams where fish prefer to inhabit.

The purpose for a whitewater feature is to develop an extreme environment which creates a hydraulic jump, increased velocities, vertical drops with high slopes and the resulting localized high shear stresses for recreation. Further, based on Colorado's observations and ours to date at the Argo Headrace, there is typically not a natural gradation of bed material along the margin of the channel to pool maximum depth as often observed in naturally occurring pools. Observations indicate that eddies circle back upstream along the downstream face of the structure and then intersect with the U drop. This eddy is lower velocity and induces deposition of fine material along the margin of the stream. The deposition of fines then extends to the grout and boulders in the pool. This results in limited transition from the fine sediment to the larger boulders leaving little transition to sand, gravel, or cobble that are important habitat for fish and aquatic invertebrates.

Model Results Associated with the Fish Passages

Page 19. To provide quantified estimates of the velocities and depths within the fish passages, REP performed a micro-analysis within the existing floodplain model. The analysis included creation of representative roughness and obstructions to determine velocity and depth within different areas of the passages. While the limits of one-dimensional modeling are documented (Toombes, et. al., 2011), we feel they provide a quantifiable comparison of existing conditions versus proposed conditions, especially when the two are directly compared, as opposed to absolute comparisons to published data. The model was run with the addition of flow conveyance distributions within the fish passage. Up to 43 vertical divisions were included at each cross section. The divisions showed average velocity over the vertical profile. It is important to note the calculations occurred over one-dimension and do not include estimates of turbulence, velocity vector orientation, and vertical turbulence. The results are shown in Appendix 6 and include screenshots for discharges of 200 cfs and 450 cfs for both existing and proposed.

To provide more valuable information on fish passages, REP compared the proposed conditions with existing conditions. As noted above in the hydraulic report, the proposed conditions model was created using the existing calibrated model as a base. Therefore, locations where no changes to the channel will occur are the same between the two models. It allows designers to directly compare model statistics between existing and proposed conditions in an "apples-to-apples" situation. We feel this type of comparison is as valuable, if not more, than setting specific criteria and comparing model results to those criteria. Regardless, we have analyzed the proposed design for both documented conditions and "apples-to-apples" criteria. Directly comparing the figures suggests the margins of the existing channel contain zones of similar velocity and depth as the proposed conditions fish passages. Because of this, REP anticipates similar fish passage capabilities between existing and proposed conditions.

DNR has already addressed what we believe are the limitations of the HEC-RAS model and its usefulness for fish passage. However, the model for cross sections at the crest and exit of structures 1 and 2 were run at 200 and 450 cfs and had predicted velocities of 4.5 cubic feet per second (cfs). The Huron River Watershed Council measured velocities at the structures in the Argo Headrace as presented in the table above. Measured velocities at the crest of the existing structures were greater than what HEC-RAS predicted for the proposed structures and measured velocities in the mid chute and exit are approximately two times of that predicted and shown graphically in the HEC-RAS model runs. Inquiries were made to DEQ to determine if model runs had been conducted for the structures in the Argo Headrace to determine how well HEC-RAS performed to the as-built conditions, however, no modeling of velocities were provided as part of the permit.

As noted by the applicant in the "Alternatives Section" the proposed whitewater features have been designed for use by moderate to advanced kayakers. It is our understanding from meeting with Gary Lacy, REP, that the structures constructed in the headrace were designed for beginning kayakers and the new proposed structures would be more aggressive. Therefore, velocities may be greater in the proposed structures than those in the Argo Headrace.

The concern with high velocities is further supported by velocity measurements taken by the United States Fish and Wildlife Service (USFWS) and DNR at cross channel structures on the Bear River in Petoskey, Michigan which were designed by REP. Velocity measurements were taken with an Acoustic Doppler Profiler and checked with a Marsh-McBirney flow meter. Velocities greater than 10 fps and up to 13 fps were measured just below the crest of these structures in spring of 2012. Velocity measurements were taken while water surface elevation was approximately one foot below bank full elevation. Since the cross channel structures considerably reduce bank full cross sectional area it would be expected that velocities potentially would increase as flows reach bank full elevation and would continue to increase until the structures flood.

Interestingly, work conducted by Colorado Division of Parks and Wildlife has measured similar velocities at cross channel whitewater structures at several locations through Colorado and the USFWS and Nevada Fish and Game have measured similar velocities at structures on the Truckee River in Nevada. Due to the high velocities and resulting lack of fish passage the United States Army Corps of Engineers is requiring modifications to be made to structures at *the Rockpark Whitewater Park on the Truckee River in Nevada to meet permit conditions requiring fish passage.*

The applicant speaks to the physical aspects of fish passage in the application; however the behavioral aspects were not addressed. There are a number of behavioral concerns associated with the proposed vertical-slot fish way. The first relates to the location of the vertical-slot fish way within the structure and the river itself. The fish way is located with in the center third of the channel. This is problematic relative to fish behavior as the applicant pointed out fish typically travel up the margins of the stream in the outer thirds of the channel where velocities are reduced due to increased roughness.

Behaviorally, the entrance of the fish way is not located in an area of the stream most often used for upstream movements thereby limiting its effectiveness. The fish way is constructed at an angle within the structure where the crest is nearer the center of the stream and the exit angles toward the outer bank. If it were accepted that velocities were low enough that allowed for fish passage at the exit (downstream at the exit) and through the fish way the fish would have to exit the structure (upstream at the crest) where cross sectional area is greatly reduced and flows become more laminar as it is directed through the U drop structure. Fish passage effectiveness is again compromised as laminar flow is not conducive to fish passage. As discussed earlier fish rely on hydraulic diversity for effective upstream passage.

Also, the cross currents created, by design are problematic for upstream fish passage from a behavioral perspective. As water passes over the structure, back eddies are created and re-circulated along the margins of the stream, along the face of the structure until intersecting with the flow through the U drop. These cross currents are troublesome for fish since they have evolved over thousands of years swimming into the current. While downstream and outside of the influence of the structure, fish will typically be travelling upstream in the outer margins of the stream swimming against the current. However, once they encounter the reverse flow of the back eddies they will need to rotate their bodies 180° degrees so that their heads are oriented downstream. In essence, they need to swim backwards to go upstream. Once the face of the structure is encountered the fish need to determine the location of the three-foot vertical-slot fish way, which is less than 3% of the current bank full width. They will have to reorient their bodies 90° to again face the current as they travel across the face of the structure to travel to the vertical-slot fish way. Upon reaching the opening, fish will then have to reorient their bodies 90° to turn upstream where the water is passing through the structure. The orientation of the fish prior to turning into flow will be broadside to the high velocities through the structure and at or near location of the hydraulic jump (Aadland personnel communication 2012).

Based on measurements taken by DNR, Huron River Watershed Council, and the USFWS at existing U drop structures in the Argo Headrace and at the Bear River in Petoskey, the high velocities will likely result in the fish being swept downstream. Even if the fish are able to orient themselves in an upstream direction the water velocities are greater than the burst speeds of almost all fish species inhabiting the Huron River.

This is based both on fish behavior and measured exit, through and entrance velocities from similar cross channel structures in Michigan and measured by the Colorado Department of Parks and Wildlife in Colorado, the USFWS and Nevada Department of Fish and Game. Cross channel U drop dam structures were constructed on the Bear River and a condition of the permit is that fish passage is a required. Based on velocity data collected by the USFWS and DNR fish passage is questionable at many of these structures. Additional work is planned to further evaluate.

Based on the information collected, and the observations and experiences from multiple agencies, ***DNR does not believe fish passage will be similar to existing conditions or be effective for unimpeded fish passage for all species, at all times of the year for all life stages.***

Sediment Transport

Page 20. "REP completed a sediment transport analysis for the project. The analysis was particularly important because of multiple factors: 1) Structure #1 is located above the invert of the channel and could potentially create backwater conditions conducive to sediment deposition and habitat degradation, 2) the material placed upstream of Structure #1 should be relatively stable and maintain sediment transport competence. Because of these two factors, the analysis focused on determining the particle entrainment threshold and associated particle sizing. Once the sizing was determined, REP completed design and quantification of the material that would be placed, and the approximate particle size that could be effectively transported in a dynamic equilibrium upstream of Structure #1.

Particle-entrainment calculations usually focus on thresholds associated with the dominant discharge (a.k.a. channel forming discharge). This discharge has been defined in a number of ways (Leopold, 1964) but is commonly known to be somewhere near the 1.5- to- 2-year recurrence interval flood. Because the 50% (or 2-year) flood for the project site was provided by the DEQ, REP chose this value as an approximation to the actual dominant discharge. The calculations provided a range of values suggesting variability in the accuracy."

"REP used the dominant discharge to estimate particle entrainment thresholds for five different methods. Those methods were: 1) Meyer-Peter Muller, 2) Competent Bottom Velocity Method, 3) Lane's Tractive Force Theory 4) Shield's Diagram, 5) and the Urban Drainage and Flood Control District method. ...Multiple methods were used to provide a range of values and ultimately, better engineering decisions."

"The results suggest the particle entrainment threshold within the project reach occurs for material sized between 114mm (4.5 in.) and 29 mm (1.1in.). Specifically, the majority of sediment transport within the project reach occurs near the dominant discharge of 2,900 cfs and particles smaller than 114 mm to 29 mm are effectively transported through two methods."

As indicated earlier in the written comments, determination of bank full while conducting the geomorphic survey is paramount in order to understand and evaluate how the river system currently is functioning and predict how perturbations to the system may effect it. Without this information we largely are just guessing what "may" happen.

The applicant references that the bank full or dominant discharge is near the 1.5- to 2- year event. As the applicant explains they chose the 2-year return interval with a discharge of 2,900 cfs. DNR concurs with the applicant that dominant discharge (aka. bank full discharge) is important as it relates to particle entrainment calculations. Hence, it is therefore necessary to conduct the appropriate survey and gage analysis to determine the dominant or bank full discharge

The Michigan Stream Team developed regional curves by conducting surveys that included cross-sections, longitudinal profiles and pebble counts at USGS Gage stations throughout Michigan (Rachol and Boley-Morse 2009) and found that bank full discharges in Michigan recur *more frequently than every two- years. Rosgen (1996) has documented the bank full event to range from one to two years.*

DNR and DEQ staff conducted a detailed geomorphic survey of the Huron River from Argo Dam to the Wall Street USGS Gage using protocol detailed by (Rachol and Boley-Morse 2009). The survey extended to the USGS Gage in order to validate the bank full indicators identified and relate it to a known datum for stage, discharge and reoccurrence interval.

Bank full discharge, cross sectional area, depth, and width relative to drainage area were compared to that determined for the regional curves developed by the Michigan Stream Team for southern Michigan. The regional curves for southern Michigan only extend to drainage areas of approximately 400 square miles while the drainage area of the Wall Street USGS Gage is 729 square miles. Even though the drainage area for the Wall Street Gage is outside the regression developed for the above parameters measured values were input into the regression to determine if they would fall within the confidence intervals and provide additional confidence in bank full verification. The analysis determines that the above parameters fall within the confidence limits.

Using the geomorphic survey and protocol referenced above the reoccurrence interval of the Huron River at the Wall Street USGS Gage was determined to be 1.32 years. The stage discharge relationship correlated a flow of 1521 cfs associated with the bank full elevation. The importance of conducting the appropriate survey becomes obvious as the dominant discharge or bank full discharge is nearly half of what was utilized by the applicant to calculate incipient point of motion for sediment transport. The difference in discharge will have substantial effect on predicted sediment competence.

A bar sample was collected in the Huron River within the proposed project area as described by Rosgen (2008). The purpose of the bar sample is to measure the largest mobile particle size in the stream. To maintain stream stability the stream must be competent to transport the largest size of sediment available and the capacity to transport the load on an annual basis. The largest particle collected and measured on the bar was a 75 mm particle.

The interpretation of the bar sample analysis indicates that the Huron River currently has sufficient shear stress to move the 75 mm particle. Based on the data collected during the detailed geomorphic survey of the riffle cross section the calculated depth required to move the 75 mm particle is 2.76 ft while the actual bank full depth is 3.15 ft. The Colorado Curve predicted the largest moveable particle size of 90.15 mm at a bank full shear stress of 0.491. The Colorado Curve developed by Rosgen most closely represented the actual measured particle size moved relative to the methods chosen by the applicant however the Colorado Curve over predicted measured values by 15 mm. The available bank full shear stress is greater than that required to move the D_{100} so excess bed scour would be anticipated. Using competence alone the prediction would lead to degradation of the channel.

The applicant used five separate sediment transport equations with an associated discharge of 2,900 cfs to determine entrainment or incipient point of motion. The predicted incipient point of motion ranged from 29 mm to 114 mm. However no justification is provided by the applicant for which of the methods are most appropriate for predictive purposes. The consultant states that, "Multiple methods were used to provide a range of values and ultimately, better engineering decisions." DNR does concur with this statement as rigorous data collection and analysis are necessary to determine actual particle entrainment.

Based on the applicants analysis they offer that particles smaller than 114 mm to 29 mm are effectively transported through the system. DNR has a number of concerns with the analysis. The first being the discharge used to determine sediment transport, the second is that the calculations used generally under predict the size of material transported as the equations were developed largely in homogenous materials not in heterogeneous materials which occur in the Huron River. This is the importance of collecting a bar sample in order to verify competence. Lastly, unless field analysis is conducted the equations predict different incipient point of motion therefore; differing results will occur depending on the method chosen however it is not known what is correct.

It is not clear to us based on the information provided if the shear stress is great enough to move material only up to 29 mm or 114 mm in size? This distinction in size of material that can be transported is necessary in order to determine if material supplied into the system can be transported. Lastly, it is our understanding that the analysis was conducted for the current slope of the existing stream. We were not able to locate any information on the incipient point of motion for materials upstream of each of the structures with the associated change in slope.

The development of the two proposed structures may not change the overall slope of the river in this reach however there will be a flattening of water surface slope above the structures and the majority of the change in elevation will occur as drops over the two structures. DNR conducted analysis based on the reduction in slope from 0.25% to 0.15% above structure 1 and the largest particle predicted to move was 78.24 mm using the Colorado Curve. This was a reduction of 12 mm from the higher slope associated with existing conditions. The required bank full mean depth, required to move the largest bar particle, is 4.6 ft and the calculated existing bank full mean depth is 4.33 ft. Decreases in slope affect stream unit power and the ability to transport sediment; thereby leading to aggradation over time and an increase in fines.

Based on DNR data collection and competence analysis the stream is capable of moving the D_{100} particle size and predicts that the stream is degrading (down cutting). However to determine stream stability competence and capacity must be considered. Based on competence alone sand particles 2 mm in size or less in diameter could easily move through the system. However pebble count data collected at the riffle, pool, reach and bar depict a bimodal grain size distribution (Attachment 5).

The bimodal distributions indicate that although the river has the competence to transport 2 mm particles, that supply is high and does not have the capacity to move all of the sand out of the river; therefore the stream bed is infiltrated with sand under existing conditions. Flattening of water surface slope above the channel spanning structures will reduce velocities and shear stress upstream, reducing transport of sand and smaller particles inducing deposition of fines thereby reducing bed slope and covering existing quality bed material which is currently comprised largely of gravel and small cobble.

The prediction model FLOWSED/POWERSED was used in order to evaluate and predict if changes in channel dimension, profile, slope and velocity of the proposed structures will affect the capacity of the river channel to transport sediment (Rosgen 2006). A description of the model can be found in Watershed Assessment of River Stability and Sediment Supply (Rosgen 2009).

To run the model suspended or bed load data need to be collected for model inputs. Since no data were collected by the applicant DEQ staff obtained discharge and suspended sediment data from seven USGS gauging stations within the same hydrophsyiographic region in southeast Michigan as the Huron River. The assumption was made that each of these gage *stations had the same bank full return interval of the Huron River at 1.32 years as measured at the USGS Wall Street Gage.*

Regression relationships were developed from discharge (cfs) to suspended sediment concentrations (mg/l) for each of the gage sites. A return interval of 1.32 years was used to determine the corresponding bank full discharge and associated suspended sediment concentration. The bank full suspended sediment concentration for each plot was then used to develop a regression for the seven gage sites in southeast Michigan. The regression equation y=0.0477x+0.0439 ($r^2$0.81) was used with the bank full flow of 1521 cfs determined for the USGS Wall Street Gage location. The suspended sediment concentration was calculated at 72.99 mg/l.

No bed load sampling was conducted so estimates were needed to determine bed load transported through the project reach. To develop an estimate of bed load, data collected by the USGS was utilized (Emmett and Leopold 1980). Bed load data was collected from a belt sampler on East Fork River near Pinedale, Wyoming. The East Fork is comparable to the Huron in that it is a gravel bed stream, C4 stream type within a valley type 8 (terraced alluvial valley) with at slope of 0.004. Based on the detailed geomorphic data collected the Huron River below the project reach is a C4 stream and the stable state of the project reach is a C stream type but the dam and the location of berms has resulted in a class change to an F4. At bank full (1760 cfs) the East Fork has a measured bed load of 1188 tons/day. Suspended sediment was 210 mg/l or 998 tons/day for bank full with total load at 2,186 tons/day, thus bed load was 54% of the total load.

Because the Argo Dam and its associated impoundment are located upstream of the proposed structures bed load would be expected to be reduced from what was measured on the East Fork. Based on bar sampling, pebble count and Pfankuch rating on the proposed reach bed load continues to move through the system. Bed load supply may derive from the banks or be transported through the Argo Dam because it has bottom draw gates. For the model run the assumption was made that 15% of the total load (tons/day) consisted of bed load.

Suspended sediment concentration was developed from regression equations, bed load concentration was estimated by using data from a river that has the same valley and stream type and an estimate was made in the percent reduction of bed load due to the upstream dam. In order to determine capacity and the ability of the river to continue to move sediment efforts were made to utilize suspended and bed load data collected by the USGS to best predict transport in the project reach.

Powersed uses sediment rating and flow-duration curves to determine annual sediment yields and is able to predict changes in degradation and/or aggradation within the cross section. In this particular case a detailed riffle cross was surveyed upstream of structure 1 and located near the applicant's cross section 2354.5. The model was run for existing conditions at the riffle cross section with a bank full flow of 1521 cfs and the model predicted that 10,540 tons/year of sediment are transported with 6,924 tons being suspended sediment. The model was then run with the structure 1 in place using HEC-RAS data provided by the applicant. The predicted water surface elevation at bank full for the riffle cross section was 764.29 The Powersed model was run with structure 1in place and predicted total sediment was 3,991 tons/year with 3,149 being suspended sediment (Attachment 6).

Even though bank full shear stress was greater than that required to move the D_{100} and using competence alone degradation of the channel was predicted. Capacity and supply need to be considered in sediment transport. The Flowsed/Powersed model predicted that sediment *transport would be reduced by over 7,000 tons per year in the proposed channel, thereby causing channel aggradation. The predicted amount of aggradation converts to 5,885 cubic yards. To place into context, if suspended and bed load was spread evenly over the Huron River channel from Argo Dam to the structure 1 a distance of approximately 1090 ft and a measured bank full width of 102 ft sediment would be over 1.3 ft deep over what currently exist. An argument could be made that model results should be carefully applied as a "true" quantity because model parameters were calculated and bed load estimated because sediment data were not collected. However efforts were made to use data collected by the USGS to predict the accurate model inputs. Most importantly the modeling efforts predict that once the structure 1 is constructed sediment deposition will occur upstream of the structure.*

The concern of sediment deposition behind these structures is not unfounded this concern is also shared by the USFWS. Below is an excerpt provided as part of August 7, 2008 USFWS Biological Opinion (2008) on Rockpark Whitewater Park located on the Truckee River in Reno, Nevada. The USFWS developed their opinion based on their experiences with sediment deposition within Wingfield Whitewater Park on the Truckee River. Information on the Wingfield and Rockpark Whitewater Park can be found on REP's website at "http://www.boaterparks.com/projects_new_list.html".

"Sediment/ Debris Transport

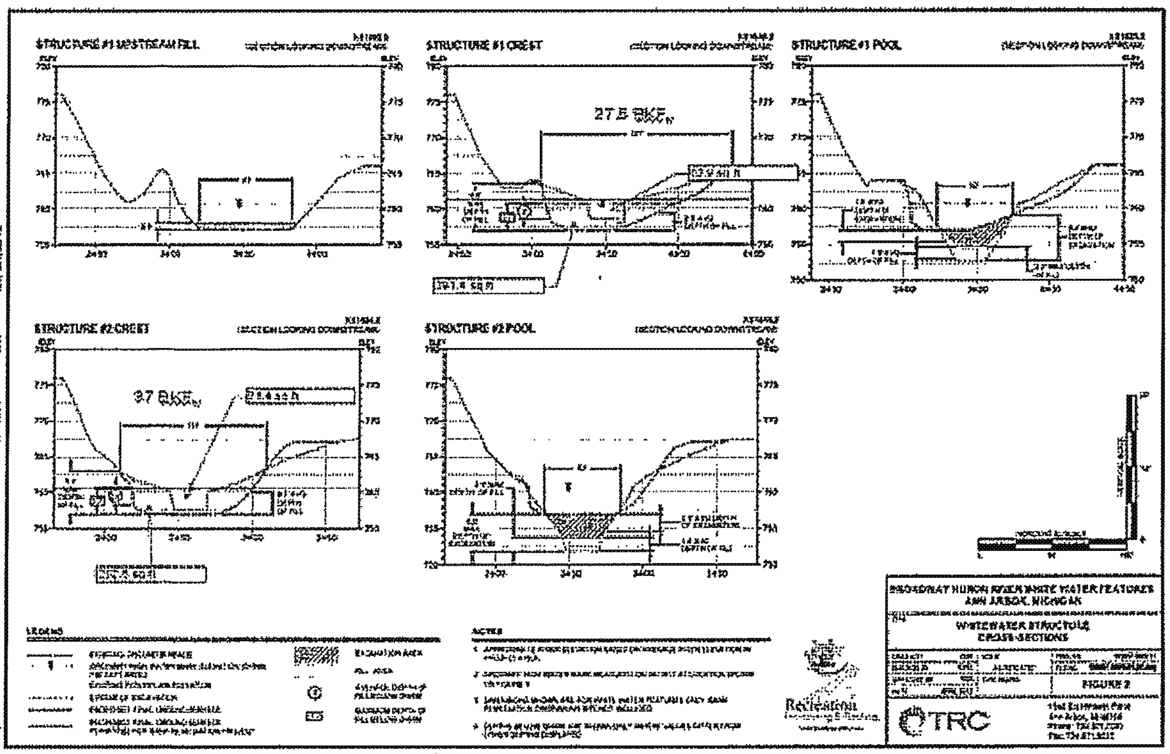
Past efforts to control the Truckee River have contributed to understanding the geomorphological processes that demonstrate rivers as being dynamic and often not responding well to efforts to contain or direct them. The proposed project site is relatively stable with little erosion and adequate sediment transport capabilities.

Due to structural design similarities with the whitewater facility at Wingfield Park upstream in Reno, Nevada, resource agencies are concerned about adverse impacts of the proposed project on sediment/debris transport. The 2005-2006 flood event resulted in substantial sediment/debris deposition at the Wingfield Park facility associated with the hardened structures in the river. As a result of the significant deposition of materials, it became necessary to dewater the river to allow excavation equipment to enter the river channel and restore the whitewater park features. This activity took place at a time when instream construction activities are normally prohibited and further impacted spawning success of brown trout and mountain whitefish. Additionally, the extensive amount of sediment that was released downstream of the excavation activities settled into the gravels, which likely resulted in suffocation of fish eggs deposited downstream of the affected area. Not only does sediment suffocate eggs, it limits invertebrate production which is the primary source of food for the river fishes. The full extent to which these activities negatively impacted the fishery can only be speculated, but it serves as an example of how the proposed project can have an ongoing negative impact on the river and associated aquatic species. Given that these natural high water events tend to occur on the Truckee River every 10 years or so, resource agencies anticipate the repeated implementation of significant maintenance measures which are highly destructive to aquatic habitats and communities in the years to come.

Given these concerns, proposed structures shall not disrupt or curtail sediment or debris transport by decreasing water velocities upstream of the structures and allowing new silt depositional areas to form upstream, within, or downstream of the structures. Any damming effect can eliminate preferred fish habitat through sedimentation and interfere with the necessary downstream drifting of aquatic invertebrates. It will also increase facility maintenance requirements."

Woody debris or other blockages in a stream may be desirable for both physical and biological channel functions, however, when the magnitude and frequency of debris is such that the stream aggrades, loses sediment transport capacity and provides fish migration barriers, then the debris is likely adding to sediment supply and instability. Debris-driven supply increases can often result in avulsions, lateral migration or stream bank or side-slope rejuvenation, which often accelerate mass failures. These blockages also include check dams, diversion structures or similar structures (Rosgen 2008). The structures proposed in the Huron River are similar to check dams or often called U drop dams and both the magnitude and frequency of the channel blockages may likely result in instability issues.

Based on personal experience Verry (personal communication 2012) has observed that once blockages exceed twenty percent or greater of the bank full cross sectional area that the channel will often seek adjustment to regain the cross sectional area. From information provided by the applicant the bank full cross sectional area at the location of structure 1 would be reduced from 291.4 ft² to 63.9 ft² or 78% while at structure 2 bank full cross sectional area would be reduced from 252.6 ft² to 71.4 ft² or 72%. Bank full width at the location of structure 1 would be reduced from approximately 90 ft to 27.5 ft and the location of structure 2 bank full width would be reduced from approximately 88 ft to 37 ft.



The structures proposed have been observed to have many of the same effects as check dams. Using the Rosgen Classification this reach of the Huron River is classified as an F4 channel. F channels with medium stage check dams have been found to cause increased stream aggradation, accelerated bank erosion, slope rejuvenation and floodplain encroachment (Rosgen 1996).

General Comments on the Application

Water Quality/Quantity Issues
A Concept Design prepared for the City of Ann Arbor (Lacy 2008) shows water quality issues related to E. coli and human contact were considered in the design by bypassing Allen Creek flow downstream of the proposed project. This excerpt is taken from the November 2008 Concept Design Report "The whitewater features will be separated from Allen Creek by a flow separator island. This will allow pollutants from Allen Creek to be separate from the whitewater project that will have full-body contact." As the design currently exists in this application, there is nothing indicating flows from Allen Creek will be separated from the Huron River as stated above.

DNR's letter dated April 24, 2012 (Attachment 7) to the City of Ann Arbor addresses water quality data collected by the Huron River Watershed Council that indicates that the Huron River below Argo Dam is designated by DEQ as not meeting full body contact standards due to high levels of E. coli. DNR has concern about increasing full body contact use in this stretch of the river with the poor water quality as it relates to resource and human health issues. The Huron River Watershed Council report indicates that the Huron River between Argo Dam and Geddes Dam continues to remain on the state's list of impaired waters due to bacterial contamination and that monitoring efforts indicate that efforts to reduce bacterial contamination have not been successful (Lawson 2011).

In the same letter, DNR addresses issues with erratic flow issues that have been measured and documented at the USGS Wall Street Gage which is located downstream of the Argo Dam and the proposed structures. DNR has been working with the City of Ann Arbor and the Federal Energy Regulatory Commission (FERC) to identify and address the erratic and inconsistent flows (i.e. large fluctuations and saw tooth hydrograph) that are recorded at the gauging station. The origination of the source or sources of the erratic flows is important as stage may increase well over a foot with a resulting change in discharge of hundreds or thousands of cfs in a matter of minutes (Attachment 8).

These rapid shifts in the hydrograph are unnatural and may be having detrimental impacts on aquatic biota and stream geomorphology. Further, these rapid flow fluctuations may be a serious public safety concern for users in the Huron River. DNR will continue to work with the City of Ann Arbor, FERC and other stakeholders to address these issues.

Most recently, water flow issues surrounding the Huron River received considerable public scrutiny as a result of low water levels between the Argo Dam and the outlet of the headrace. DNR sent a letter dated July 31, 2012 (Attachment 9) to the City of Ann Arbor concerning the flow issue after receiving a number of complaints about the dewatered condition of this stretch of river.

Specifically, the letter outlined concerns which included the un-natural flow hydrograph as recorded at the USGS Wall Street Gage and a recommendation for minimum flows. The City of Ann Arbor responded later in the week that they would not adopt the DNR's minimum flow recommendation and planned to continue to operate as they have. The fact that no operational plan was ever developed has resulted in controversy and potential resource damages to the state's public trust resources.

The diversion of flow from the Huron River to the Argo Headrace has not been resolved by the resource and regulatory agencies, City of Ann Arbor, and other stakeholders for the existing structures to date, nor does the current permit application address flow management for the proposed structures. The Huron River through Argo has had well- documented flow issues through Ann Arbor for twenty years that have largely remained unresolved. Additional complications to the system with the existing structures and newly proposed structures will not improve the situation. The question should certainly be asked that if the proposed structures are constructed, is there adequate flow in the Huron River during the low flow summer months, in most years, to facilitate operation of the structures as designed for both the Huron River and the Argo Headrace? Based on the period of record for the USGS Gage, average daily flows in July and August may potentially not be high enough to facilitate operation of structures in both the river channel and headrace. The question above speaks to kayak recreation, however, the same question must be asked of the effects on resource impacts.

Channel Changes
As detailed above, modifications to the existing channel are significant immediately due to construction. The applicant states, based on the sediment transport analysis and proposed channel fill above structure 1 that the slope remains constant and the reach should maintain a dynamic equilibrium. DNR does not concur with this statement in that 231 cubic yards of fill are proposed to be placed in the existing bed upstream of structure 1 encompassing an area 63 ft wide, 110 ft long and a depth of 0.9 ft. The proposed fill increases existing bed elevation, eliminates the thalweg, and reduces bed slope through this section. Changes in the existing bed material to that proposed will modify channel roughness impact flows and sediment transport.

According to the plans provided by the applicant, the maximum fill in elevation at structure 1 is 6.6 ft and 5.9 ft at structure 2 and raises the invert of the bed elevation. These constitute major changes to bedform, slope, roughness and cross-sectional area and the stream will adjust. These changes will not allow the stream to remain dynamically stable thereby maintaining its current dimension, pattern and profile and continue to transport stream flows and sediment without aggrading or degrading.

The U drop portion of the structure reduces bank full cross sectional area at structure 1 and 2 by 78 and 72 percent, respectively. The invert elevation of the U drop is elevated over two ft in height relative to the existing thalweg at structure 1 and over a foot at structure 2. The crests adjacent to the U drop are approximately 2.5 ft higher than the invert of the U drop. This rise in bed elevation changes slope of the stream considerably. Bed slope upstream of structure 1 is reduced from 0.33% to 0.019% (Attachment 10).

The Huron River between Argo Dam and the outlet of the headwater currently is not impounded, is relatively high gradient with valuable riffle, glide, and run habitat, and has considerable in-stream woody habitat particularly on the river left (north side). This is high-quality habitat in any river system, but particularly in an urban setting. As mentioned previously, un-impounded water in the Huron River through and near the City of Ann Arbor is limited. From Huron River Drive, upstream of Barton Impoundment, to Belleville Dam, there is approximately 29.2 miles of river of which only 11% is not impounded.

Pebble count data collected documents that the bed substrate is quality habitat which consist of heterogeneous material comprised largely of gravel, cobble habitat and occasional boulders. Development of cross channel structures reduces slope of the existing reaches upstream of the structures creating impounded areas thereby reducing limited bedforms and habitat.

Clearly, based on the information provided by the applicant and analysis conducted by DNR, the proposed structures will change the character of the stream from a riffle/pool sequence stream to that of a step/pool system. The proposal modifies the existing stream into a channel type that is not stable based on the natural slope of the valley. Although overall slope of the channel may remain the same as it is currently, facet to facet slope changes, thereby inducing channel changes in flow, bedform and planform.

Water surface slope flattens as a result of these structures thereby reducing velocity and shear stress between structures inducing sediment deposition and the accumulation of fines behind the structures. As the applicant clearly states, drop structures will be constructed with grout to hold the structures together. This speaks to the fact that these structures are not stable in the existing system and cause instability.

Any instability in the river geomorphology should be seriously considered since it is physically tied into the remediation work permitted at the MichCon site. As referenced in the Sediment Transport section above, F channels with medium stage check dams have been found to cause increased stream aggradation, accelerated bank erosion, slope rejuvenation, and floodplain encroachment.

Biological Issues
Biological assessments of fish and aquatic invertebrates were not conducted by the applicant as requested by DEQ and supported by DNR staff during the initial meeting. However, historical and recent surveys of fish and other aquatic organisms in the portion of the Huron River downstream of the Argo Dam have found several State endangered, threatened, and/or special concern mussels and fish species to be present in the area. The most recent survey work conducted in July of 2012 by University of Michigan mussel expert, Renee Sherman Mulcrone, found live individuals of the State threatened Wavy-rayed lampmussel (*Lampsilis fasciola*) and evidence of the state special concern species Elktoe (*Alasmidonta marginata*) and Kidneyshell (*Ptychobranchus fasciolaris*) in the immediate area of the proposed structures. Other historical surveys (as recorded in the Michigan Natural Features Inventory database) have found the state threatened Purple wartyback (*Cyclonaias tuberculata*) and Slippershell (*Alasmidonta viridis*), and special concern Paper pondshell (*Utterbackia imbecillis*) and Rainbow (*Villosa iris*) mussels. The state endangered northern madtom (*Noturus stigmosus)* and southern redbelly dace (*Phoxinus erythrogaster)* have also been reported downstream of the Argo Dam.

<u>Changes to the river flow and habitat characteristics in the vicinity of the proposed structures could significantly effect the populations of these protected species in this portion of the Huron River.</u> Fish passage problems could affect mussel distribution and survival as mussels have an obligatory parasitic stage on fish. In fact, certain mussels have become functionally extinct because of the restricted movement of host fish. Water velocities through the proposed structures would impede fish passage in this portion of the river with potential effects on both current and future fish communities.

User Conflict
The current issue related to flow through Argo Dam and the headrace highlights the conflict between and among user groups. Currently the City of Ann Arbor operation plan is to provide 60 cfs through the headrace while the Huron River immediately below Argo Dam may be receiving less flow during low-flow periods such as has been experienced in July and August 2012. There is considerable concern from the DNR and public, as addressed in the July 31 letter, and flow management has caused conflict between users of the existing structures and long-term recreationalists who have established uses below the Argo Dam and the headwater outlet.

This conflict is not surprising; for years there has been conflict in Michigan among canoers and anglers in several rivers for competing uses. Kondratieff (2012) cites a study conducted in 1996 by the State of Wyoming, Fish and Game to determine why anglers fished. The top reasons are listed below:

1. Opportunity to be outdoors
2. Relax
3. Get away from people
4. Fish in pleasant surroundings
5. Catch good tasting fish
6. Hook/land large fish

Similarly a survey was undertaken in 2008 by the Colorado Division of Wildlife, preferences at to why people fish in Colorado were:

1. Relax
2. Be close to Nature
3. Be with family
4. Get away from others
5. To catch and eat fish
6. "Trophy" fish

The work conducted by Kondratieff addresses that there are potential compatibility issues between whitewater park users and anglers. The information collected during the creel survey from anglers also inquired about preferences and problems. Anglers responded that aesthetics are highly valued, stream anglers prefer to fish in a natural setting and "pleasant surroundings" and prefer to fish without crowds and "get away from people." Colorado believes that angler use has been reduced in natural rivers where whitewater park structures are constructed due to the compatibility issues discussed above as well as reduced fish biomass.

In a July 29, 2008, column written in the Pagosa Daily Post, Bill Hudson interviewed Bill Whittington, whose family owns the Springs Resort which is located on the on the banks of the San Juan River next to a whitewater structure in Pagosa Springs, Colorado. Whittington told Hudson that there is no conflict between fishermen and boaters when the boaters are floating through the w-weir structure (natural channel design structure), but when a stoppage in the river like the Davey Wave (whitewater structure) was constructed, problems began between boaters and fishermen (Attachment 11).

As evidenced by the flow issues, conflict has already begun. The question currently is, during low-flow conditions, are flows provided to operate the new structures in the headrace for the designed 60 cfs or to provide flows to the Huron River for established recreational uses and biological needs below the dam? This topic is important to address not only because there is an established use, but because DNR and its partners have been working to introduce and improve urban fishing opportunities and experiences. If flow and compatibility issues are not adequately addressed, opportunities for urban fishing may be further reduced.

Cross Channel Structures Relevance to Stream Crossings

DNR's policy (No. 02.01.007) on Stream Crossings reads (Attachment 12), "The most important objective when considering a new, replacement, or temporary stream crossing is to maintain a free-flowing, natural stream channel. Fisheries, hydrology, recreation, water quality, and aesthetics can all be significantly degraded by poorly designed, constructed, or maintained stream crossing."

Cross channel structures dependent on flow conditions may act similarly to concrete culverts. This occurs when flows pass through the U drop and is not flowing over the wings. Physically, the U drop will be 19 ft long dropping one foot in elevation from the crest to the exit having a slope of approximately 5%. In fall of 2011, DEQ adopted rules for General and Minor Permit Categories addressing installation of culverts to allow for natural stream processes and aquatic organism passage. In order to allow for these conditions culverts are to be buried 1/6th of bank full depth, span the bank full channel, be aligned with the stream, and be placed on the same slope of the stream.

Certainly, an argument can be made that the U drop portion of these structures act similarly to concrete culverts placed at a slope that is high relative to riffle to riffle slope in the stream and are perched above the streambed on both the upstream and downstream end. The effects of these structures are in many ways similar to an improperly installed culvert as it relates to sediment transport, localized scour and aquatic organism passage.

Michigan Stream Team

Staff from state and federal agencies formed the Michigan's Stream Team in 2002. The Stream Team consists of governmental agencies in Michigan which are involved in various aspects of stream geomorphology including studying stream function, channel stabilization, and rehabilitation. An important component of the Michigan Stream Team as outlined in their mission is to:

- Train agency and stakeholders on stream morphology
- Serve as a technical resource to advance stream morphology science to Michigan agencies and interest groups

The Michigan Stream Team developed the document titled, "Michigan Stream Team White Paper Whitewater Parks" dated May 2012 (Attachment 13). The Michigan Stream Team suggest that whitewater park structures, like all man-made, in-stream structures, have the potential to negatively impact stream hydrology and hydraulics, sediment transport, channel morphology, and ecology, which collectively are known as stream function.

The white paper continues that, "The primary goal of any stream construction project should be to maintain or restore stream function. Stream function is defined in the Clean Water Act as the physical, chemical and biological processes that occur in ecosystems. Stream function concerns specific to whitewater parks include:

- Accommodation of the stream's seasonally variable hydrology without triggering geomorphic instability in the channel or interfering with other stream functions such as organism passage.
- Conveyance of the stream's sediment, organic material, and woody debris loads.
- Connectivity for fish, macroinvertebrates and other aquatic organisms.
- Loss of interstitial habitats for fish and macroinvertebrates.
- Maintenance of hyporheic exchanges.
- Disruption of riparian habitat.
- Degradation of water quality.
- River dynamics."

Many of the stream function concerns were addressed previously in our comment letter; however, the white paper is comprehensive and expands on the above topics. DNR concurs with the comments developed by the Michigan Stream Team and contained within the whitepaper as it relates to channel-spanning structures.

American Whitewater, an organization focused on protecting and restoring rivers, developed a Whitewater Parks Policy Statement Developed May 2007 (Attachment 14). American

Whitewater has a direct interest in whitewater parks that will either significantly impact a river or that will restore significant ecological or social values to an impaired river. It is American Whitewater's policy that natural un-modified river channels should not be modified for the creation of whitewater parks. Bulleted points below address issues American Whitewater believes need to be considered in any proposed whitewater park design and construction process.

- Instream flows- diversion of water to off-channel or features that result in a loss of stream flow.
- Riverbed condition -alteration of a natural unmodified riverbed to a less natural state.
- Fish passage - changes to the streambed reduce or eliminate upstream and/or downstream passage of fish and other aquatic species.
- Pre-existing and potential recreation values - recreational uses such as whitewater boating, calm-water boating, angling, swimming, or sightseeing are impacted or limited through park or feature construction.

American Whitewater staffer Kevin Colburn (2012) authored the document titled, Integrating Recreational Boating Considerations Into Stream Channel Modification & Channel Design Projects. The document states the mission of American Whitewater is "to protect and restore our nation's whitewater resources and to enhance opportunities to enjoy them safely. Our members are predominantly conservation-oriented whitewater kayakers, canoeists, and rafters. Our river stewardship program focuses on restoring rivers impacted by hydropower dams, protecting free flowing rivers from environmental harm, and ensuring that river management supports sustainable river recreation."

- All in-stream channel work should protect natural structure (bedrock, boulders, and native riparian vegetation) in the existing or new streambed area.
- Rivers are inherently dynamic systems and every structure placed in a stream will one day be disassembled and moved by the stream. This process should be a fundamental component of the design. Structures should be viewed as temporary, and be designed to accelerate or guide natural processes which will eventually take over.
- Regardless of any special designation, rivers belong to all citizens and should be managed accordingly. Channel design elements that appear artificial can have detrimental aesthetic impacts that can last for a generation or more.
- Generally, channel designs that mimic natural streams will benefit the ecology of the stream – and they will be consistent with natural geomorphology. For example, if the design reach is in the middle of a popular Class II whitewater river, it would be appropriate to design Class II rather than Class V rapids in the reach.

These excerpts were taken from the American Whitewater publication. DNR concurs with American Whitewater's mission statement and agrees with the bulleted points listed by American Whitewater above. DNR does not believe the current cross channel structures meet any of the bulleted items above as proposed by American Whitewater.

Natural substrate is not being protected in the existing reach as data collected clearly shows that the stream will aggrade, covering current bed material with finer particles, and much of the existing instream and riparian habitat will be removed to armor the banks with boulders.

As discussed previously in detail, the current design does not allow for natural river processes and stream function as DNR outlined at the initial meeting. The proposed structures change the bedform of the river from a riffle/pool stream to a step/pool system. Structure 1 is at the location of the only naturally occurring pool in the proposed project reach and rock is proposed to fill this pool in an upstream direction through its length. Riffles, runs, pools, and glides are naturally created and maintained in river systems to allow for the dissipation and transfer of energy thereby maintaining dynamic equilibrium. It is not sound science or engineering to disregard the existing bedform as these perturbations cause instability in the system. Rivers have a central tendency to adjust their dimension, pattern and profile to maintain and again reach stability if perturbed. The necessity to grout boulders and structures in place speaks to the fact that stream geomorphology principles for a stable stream are being violated.

Although the structures may consist of boulders which are natural material, the structures are not natural acting or looking in the Huron River. The structures consists primarily of congregated large to very large boulders (diameters of 1024 -2048 mm) grouted together. The D_{50} of this reach of stream is 26.22 mm which is classified as coarse gravel. Information was provided to the applicant on natural channel design structures; however, consultants for the applicant said they had no interest in these structures.

Lastly American Whitewater recognizes that modifying designs that mimic natural streams will benefit the ecology of the stream – and they will be consistent with natural geomorphology and offer that if the design reach is in the middle of a popular Class II whitewater river, it would be appropriate to design Class II rather than Class V rapids in the reach. Clearly, modifying this stretch of the Huron River from a riffle/pool sequence to step/pool system appears counter to what they support and is not conducive to natural stream function

Other Potential Alternatives

DNR does not concur with the applicant that modifications to the initial design serve as an alternative to the proposed project. However other options are presented as potential alternatives to the project.

- Construct an off-channel whitewater park allowing for kayaking and tubing while minimizing resource impacts and recreational conflict among users of the pubic trust resource.
- Removal or modification of the Argo Dam would allow for considerable whitewater opportunity and true rehabilitation of the Huron River up to Barton Dam.
- Address and resolve water quality in Allen Creek to address full body contact issues.
- Modify gates as necessary at Ann Arbor-owned and operated dams to allow for run of river operation which simulates a natural flow hydrograph.
- Improve operating, monitoring and data collection equipment as necessary for improved operation of dams and flow releases to the Argo Dam and headrace.
- Enhance fish passage at existing whitewater structures in the Argo Headrace. Fish passage in these structures appears limited based on velocity measurements taken at the structures.
- Explore use of natural channel design structures to address stream stability, natural stream function, habitat and recreational opportunities.

Based on our review of the data provided by the applicant for the MichCon Broadway Street MGP Whitewater and Habitat Improvement Project, specifically DEQ permit application No. 12-81-0077, and data collected by ourselves and other entities, **Fisheries Division of the DNR is strongly opposed to permitting the proposed project.** Although the project is titled as a habitat improvement project, evaluation of the information available indicates this project has substantial negative habitat and resource impacts. As the Michigan Stream Team outlines in their white paper, cross channel whitewater structures may provide other benefits, but they do not fully address stream function and are not designed and installed with documented bank full characteristics of width, depth, cross sectional area and slope.

Please feel free to contact Chris Freiburger, Elizabeth Hay-Chmielewski, or myself if there are any questions or if further information is needed.

Sincerely,

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Attachments

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Attachment 1

Fisheries Division Policy & Procedure	Program **Field Operation**	
	Chapter **Construction Impact Assessment**	Date Approved: **REVISED 02/25/2009**
	Responsible Program **Habitat Management Unit**	
Title **Dams and Barriers**		Number **02.01.002**

LEGAL REFERENCES

Michigan, acting through its Department of Natural Resources, has an obligation to preserve and protect its resources as prescribed by Article 4, §.52 of the Michigan Constitution. Fish and other aquatic organisms in the public waters of Michigan are entrusted to the State for the use and enjoyment of the public, present and future.

Part 301, Inland Lakes and Streams, of the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451, as amended.

Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451, as amended.

Part 483, Passage of Fish over Dams, of the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451, as amended.

Structures on State designated Natural Rivers systems (which include specific tributaries) are also subject to the respective Natural Rivers Plan (available on the DNR web site under Forest, Land and Waters, http://www.michigan.gov/dnr) and accompanying zoning ordinances administered by the local zoning review board, or the Michigan Department of Natural Resources, Fisheries Division. The Natural Rivers Program is established pursuant to NREPA, Part 305.

Projects which obstruct or alter navigable waters of the United States require federal review by the U.S. Army Corps of Engineers under Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403). The following projects are subject to Section 10 permit review: 10,000 cubic yards or more of wetland fill; stream enclosures of 100 feet or more; stream channelization of 500 feet or more; work in Section 10 (navigable) waters; projects which involve federal or state lands or rivers (e.g. federally designated wild and scenic rivers, federal parks, national lake shores, wildlife sanctuaries); projects that would impact federal endangered species.

For all construction related projects, refer to the following Soil Erosion and Sedimentation Control guidance documents:

- Department of Management and Budget Soil Erosion and Sedimentation Control Guidebook, February 2003 http://dnrintranet/pdfs/divisions/fish/sesc/DMB_handbook.pdf
- DNR Soil Erosion and Sedimentation Control Procedures, July 2003 http://dnrintranet/pdfs/divisions/fish/sesc/SESCProcedure7-22-03.pdf
- DNR Fisheries Division Process for Soil Erosion and Sedimentation Control, March 2003 and Addendum, September 2003

POLICY

The Michigan Department of Environmental Quality (DEQ) Land and Water Management Division has regulatory authority over all new dams, certain existing dam structures which may be periodically repaired, modified, or removed when practical, and water management practices at dams on public waters. Fisheries Division staff will review these proposed activities and provide comments and concerns to DEQ in a timely manner.

This policy does not pertain to structures that provide legally established lake levels or Federally-licensed hydropower projects (see relevant policies). For the placement of new sea lamprey barriers, the Great Lakes Fishery Commission Interim Policy will be followed (Great Lakes Fishery Commission 1999).

When dams or barriers are subject to review, Fisheries Division will recommend dam operations that mimic natural riverine conditions, protect and maintain desired aquatic communities, protect recreational uses, and where possible, rehabilitate natural resources degraded by the dam. Fish passage may be required in conjunction with dam construction, repair, or other modifications. When natural resource impacts have occurred that can be mitigated or restored through dam modification, Fisheries Division will seek modification or voluntary removal, in lieu of repair, of deteriorated dams that no longer have value or provide a service. The construction of new dams, including dams on intermittent streams or wetlands, will generally be opposed. Recommendations shall take into account social, economic, ecological, and public trust values.

For additional information, also refer the Policy & Procedure entitled: Hydropower (FERC) Licensing Study Guidance, Lake Level Management.

EXPLANATION

The adverse impacts of dams on river and stream ecosystems have been well documented (Hammad 1972, Ligon et al. 1995, Shuman 1995, Petts 1980, Cushman 1985, Doppelt 1993, Benke 1990, Bain et al. 1988, and Ward and Stanford 1989). Dams interrupt and alter most of a river's ecological processes by changing the flow of water, sediment, nutrients, energy, and biota (Ligon et al. 1995). Some of the main ecological issues regarding effects of dams include water quality degradation, prevention of fish migration, and altered flow regimes. Dams transform long river reaches into impoundments and change downstream reaches, resulting in streambed degradation (Kohler and Hubert 1993).

Protection and restoration of river environments is essential for sustainable, diverse, and productive stream fisheries. Over the last two decades, fisheries managers and ecologists have explored the changes dams cause in the ecological processes of river environments. Rivers emerging beyond a dam may be substantially altered from the character of the river entering an impoundment above a dam. Aquatic community health is closely linked to water temperature tolerances and impounded waters may discharge at significantly higher or lower temperatures than normally encountered in the stream. Water quality may decline in impounded streams if excessive nutrients, sediments, and aquatic plants accumulate in the impoundment. Flow patterns reflecting normal high and low water conditions may also be fundamentally altered, affecting stream channel configuration, fisheries habitat, and many other physical and biological processes. Stream changes induced by dams are often reflected in the fish community. Native and desirable stream species are almost always displaced in river segments affected by dams. Dams also limit the normal movement of fish, other aquatic organisms, and organic material.

Dams not properly maintained can fail during flood events, resulting in fish kills, habitat destruction, and release of large amounts of sediment that may contain toxic contaminants. Many of these effects are long-term and difficult or impossible to correct. These effects proceed in an uncontrolled manner and represent a tremendous loss of investment in the dam and in natural resource management (e.g., fish stocking and habitat improvements). Dams that no longer serve any useful purpose should be removed to avoid catastrophic failure, eliminate dam maintenance and liability costs, and to restore natural river functions. Adverse effects of dams on the health and viability of our rivers and streams can be reversed with dam removal.

The DEQ has inventoried 2,503 dams across the state. These dams range in size and function to include large actively generating hydropower dams, down to small earthen dams. The majority of these dams are small, privately owned, non-power generating dams that are not subject to the dam safety provisions of the NREPA. Many State and Federally owned dams in Michigan provide water level control for waterfowl and fisheries management purposes. . Other services potentially provided by dams include recreation, irrigation, flood control, domestic use, debris control, navigation and holding of mine tailings. Most Michigan dams are several decades old and deteriorated due to age, erosion, poor maintenance, flood damage, ice damage, and poor design. Dams in disrepair that are not modified or removed are at significant risk of failure, particularly during high flow events.

Fisheries Division will review proposed dam construction, operation, and repair and make recommendations to protect fish spawning and migration periods and to minimize other potential adverse resource effects. Where significant damage to the public health, safety, welfare, property, and natural resources or the public trust in those natural resources or damage to persons or property occurs or is anticipated to occur due to the construction or operation of a dam, Fisheries Division will recommend to DEQ that they order the owner to limit dam operations (or deny new dam construction). These orders may include, but are not limited to:

A. Operation in run-of-river mode, which is defined as instantaneous inflow into the impoundment equals instantaneous outflow from the impoundment

B. Provide minimum flow release that mimic seasonal flows to protect downstream environments in bypass channels or other river reaches
C. Restrict reservoir fluctuations during drawdown by defining a specific drawdown window to protect aquatic resources, drawdown rate (0.5 feet per day), specified refill rate, maximum range of variation in water surface elevation (bandwidth), and daily stranded fish and mussel surveys
D. Cold water releases to enhance fishery when appropriate

Fish passage will be recommended in conjunction with other permitted dam modifications or repairs, unless the dam is a functional sea lamprey barrier or is serving other fisheries management objectives. Fish passage may be recommended for a dam serving as a functional sea lamprey barrier if fish passage or sea lamprey control can be provided using alternative technologies. Dams that are petitioned to be legally abandoned, or that undergo major modifications by their owners, will also be required to provide fish passage.

Construction activities that call for a temporary or permanent drawdown of the water level of a dam impoundment will be expected to utilize sediment management practices to limit the release of material to the downstream reach of the stream. Sediment management may include controlled release, silt curtains, dredging, sediment traps, and monitoring. Drawdowns must be scheduled to minimize adverse effects to fishes, including aquatic habitat, spawning areas, and spawning periods. Because of lethal effects caused by low water, drawdown timing should also protect reptiles, invertebrates, and amphibians that over-winter by burrowing into shoreline areas.

It is well-known that dams disrupt a river's continuity and most stream channels downstream of dams have little woody debris. Wood and other vegetative materials provide important energy and habitat structure to a river system. Fisheries Division supports efforts to ensure that woody debris is passed below a dam rather than removed or held within the impoundment. Rock piles, logs, stumps, and other natural material may provide important fisheries habitat in the impoundment and should not be removed during drawdown conditions.

Because of the significant adverse environmental effects of dams, Fisheries Division does not support new dam construction.

Dam removal will be considered where the dam serves little or no purpose and there is a reasonable expectation that dam removal will benefit the environment or aquatic resources. If the dam is likely to cause significant damage to public health, safety, welfare, property, natural resources, or the public trust in those natural resources, Fisheries Division will recommend that DEQ order its removal.

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Kelley D. Smith

Kelley D. Smith, Chief

2/25/2009

Date

Attachment 2

March 7, 2012 e-mail

At the last phone conference you had asked DNR/DEQ to send criteria related to velocities that allow for fish passage and propose a sediment model that we would support. This information would then aid in design modifications of the proposed whitewater structures that allows for natural stream function and fish passage. Although we discussed these issues on the conference call, I wanted to send an e-mail to hopefully provide clarity and additional information that may assist in design modifications.

As we discussed on the phone, we have not set a specific threshold for velocity (fps). DNR's position is to have unimpeded fish passage for all fish species at all life stages at all times of the year as you would expect in a reference reach. We do use fish passage models at times to assist in evaluating if fish passage is predicted. However, this is complicated due to the distribution of velocity being far more important than are mean column velocities. This limits the usefulness of hydraulic models in predicting fish passage. While more sophisticated two- and three-dimensional models are available, like all models, they are only as accurate as the data input into them.

Further, fish swim capabilities which were largely conducted in laboratory conditions is known only for a few of the strong swimming Midwestern fish species and the information that has been collected is limited to specific sizes. This lack of data alone, not to mention numerous other variables, has made it difficult at best to accurately determine passability for all species making up the community. Therefore if stream function is maintained which meets reference reach conditions passage should occur which has been our experience.

The other issue discussed was selection of an appropriate sediment model. DEQ provided the Natural Channel Design (NCD) checklist as a guidance document to collect the necessary information which allows for evaluation of any proposed stream project. As it relates to sediment model selection the NCD checklist recommends the applicant selects a model and discuss its appropriateness with the regulatory and resource agencies.

I also wanted to note that as the NCD checklist addresses when additional geomorphic information is collected (i.e. longitudinal profile) it is necessary to collect bankfull measurements on all cross sections and the longitudinal profile in order for DNR to evaluate. My understanding is that to date no longitudinal profile data has been collected or bankfull measurements taken on any of the data which has been collected. Further reference reach information may need to be collected to determine stable conditions in order to determine appropriate design if the subject reach is deemed to be unstable based on geomorphic data collected. Often river bank and bed erosion is common in reaches downstream of dams (ACOE 1994) which may be the case below the Argo Dam.

I'm providing additional information to you that I hope is helpful when considering potential design modifications. Since I am not aware of all of the potential design options all of this information that I am forwarding may or may not be applicable. However, work that we or others have conducted in which we have had opportunity to evaluate and/or review incorporates many of these criteria to insure a dynamically stable stream (i.e. dimension, pattern and profile) are created and maintained.

The first document attached is from Dr. David Rosgen and is titled," *The Cross-Vane, W-Weir and J-Hook Vane Structures...Their Description, Design and Application for Stream Stabilization and River Restoration*". These structures have wide acceptance throughout Michigan if used appropriately in stable stream reaches. I had mentioned on the phone that a w-weir structure was built on the Grand River in the Village of Dimondale to provide grade control as a result of a dam removal but the side benefit of the project has been the use by kayakers. This structure not only has provided grade control but has allowed stream function, stable geometry, fish passage and continued recreational use that had already been established at the site.

The next document addresses work that was completed in November 2011 by Dr. Sandy Verry titled, "*Physical Evaluation of the Chesaning Rapids Shiawassee River, Michigan and Recommendations for Rock Ramp Construction in Incised Rivers*". This assessment pertains to the construction of rock arch rapids over a dam which allows for fish passage. The rapids were completed in September of 2009 and fisheries evaluations were conducted in 2010 and 2011. It determined that some fish species were able to migrate up and over the structure however other species were not successful. As a result of this investigation modifications were made to the structure in 2011 to allow for unimpeded fish passage since conditions were not met.

The document is very much worth a review - there are a few areas that I have highlighted that are paramount in order to allow for fish passage. Specifically, this relates to head loss over a structure. Dr. Verry explains that recommended step height and/or head loss has changed over the years as more of these structures have been built and we better understand what is needed. On page 26, Dr. Verry points that the best information to date suggests that step height and head loss should not be over 0.7 ft. Midwestern fish species have no or limited jump capability to traverse vertical heights greater than this distance. Further, gaps of 1-3 ft should be provided between boulders making up the structures which allow for gaps for non jumping fish to traverse through the structures and reduces velocities (page 27).

Dr. Verry has worked extensively with Dr. Luther Aadland, Minnesota DNR on in-stream structures as it relates to stream geomorphology and fish passage. Dr. Aadland author of "*Reconnecting Rivers: Natural Channel Design in Dam Removals and Fish Passage*". Dr. Aadland has found that shear stress should be less than 70 kgm^2 to allow for fish passage (page 51). Any structures designed should at minimum meet the conditions noted above.

Ultimately any structures designed should incorporate natural stream function and if those conditions are met fish passage should be able to be achieved.

This should not be considered an exhaustive list however I hope this is helpful and provides guidance that meets DNR policies and goals.

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Attachment 3

Reference tables for Manning's n values for Channels, Closed Conduits Flowing Partially Full, and Corrugated Metal Pipes.

Manning's n for Channels (Chow, 1959).

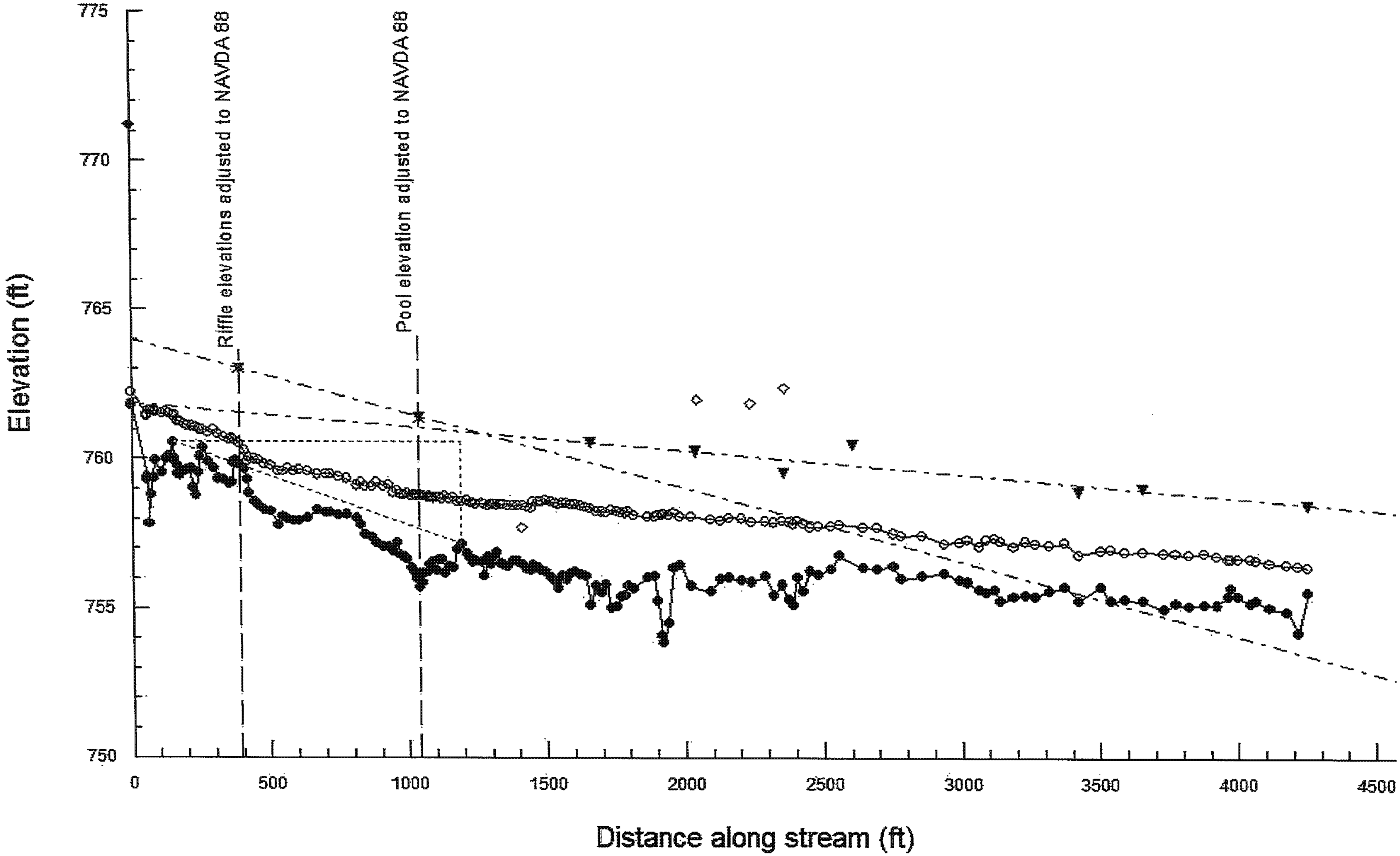
Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at floodstage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. same as above, but more stones and weeds	0.030	0.035	0.040
c. clean, winding, some pools and shoals	0.033	0.040	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.050
e. same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. same as "d" with more stones	0.045	0.050	0.060
g. sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. bottom: cobbles with large boulders	0.040	0.050	0.070
3. Floodplains			
a. Pasture, no brush			
1.short grass	0.025	0.030	0.035
2. high grass	0.030	0.035	0.050
b. Cultivated areas			
1. no crop	0.020	0.030	0.040
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.030	0.040	0.050
c. Brush			
1. scattered brush, heavy weeds	0.035	0.050	0.070
2. light brush and trees, in winter	0.035	0.050	0.060
3. light brush and trees, in summer	0.040	0.060	0.080
4. medium to dense brush, in winter	0.045	0.070	0.110
5. medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. dense willows, summer, straight	0.110	0.150	0.200

4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. same as 4. with flood stage reaching branches	0.100	0.120	0.160
4. Excavated or Dredged Channels			
a. Earth, straight, and uniform			
1. clean, recently completed	0.016	0.018	0.020
2. clean, after weathering	0.018	0.022	0.025
3. gravel, uniform section, clean	0.022	0.025	0.030
4. with short grass, few weeds	0.022	0.027	0.033
b. Earth winding and sluggish			
1. no vegetation	0.023	0.025	0.030
2. grass, some weeds	0.025	0.030	0.033
3. dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. earth bottom and rubble sides	0.028	0.030	0.035
5. stony bottom and weedy banks	0.025	0.035	0.040
6. cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. no vegetation	0.025	0.028	0.033
2. light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. smooth and uniform	0.025	0.035	0.040
2. jagged and irregular	0.035	0.040	0.050
e. Channels not maintained, weeds and brush uncut			
1. dense weeds, high as flow depth	0.050	0.080	0.120
2. clean bottom, brush on sides	0.040	0.050	0.080
3. same as above, highest stage of flow	0.045	0.070	0.110
4. dense brush, high stage	0.080	0.100	0.140
5. Lined or Constructed Channels			
a. Cement			
1. neat surface	0.010	0.011	0.013
2. mortar	0.011	0.013	0.015
b. Wood			
1. planed, untreated	0.010	0.012	0.014
2. planed, creosoted	0.011	0.012	0.015
3. unplaned	0.011	0.013	0.015
4. plank with battens	0.012	0.015	0.018
5. lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. trowel finish	0.011	0.013	0.015

2. float finish	0.013	0.015	0.016
3. finished, with gravel on bottom	0.015	0.017	0.020
4. unfinished	0.014	0.017	0.020
5. gunite, good section	0.016	0.019	0.023
6. gunite, wavy section	0.018	0.022	0.025
7. on good excavated rock	0.017	0.020	
8. on irregular excavated rock	0.022	0.027	
d. Concrete bottom float finish with sides of:			
1. dressed stone in mortar	0.015	0.017	0.020
2. random stone in mortar	0.017	0.020	0.024
3. cement rubble masonry, plastered	0.016	0.020	0.024
4. cement rubble masonry	0.020	0.025	0.030
5. dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. formed concrete	0.017	0.020	0.025
2. random stone mortar	0.020	0.023	0.026
3. dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. glazed	0.011	0.013	0.015
2. in cement mortar	0.012	0.015	0.018
g. Masonry			
1. cemented rubble	0.017	0.025	0.030
2. dry rubble	0.023	0.032	0.035
h. Dressed ashlar/stone paving	0.013	0.015	0.017
i. Asphalt			
1. smooth	0.013	0.013	
2. rough	0.016	0.016	
j. Vegetal lining	0.030		0.500

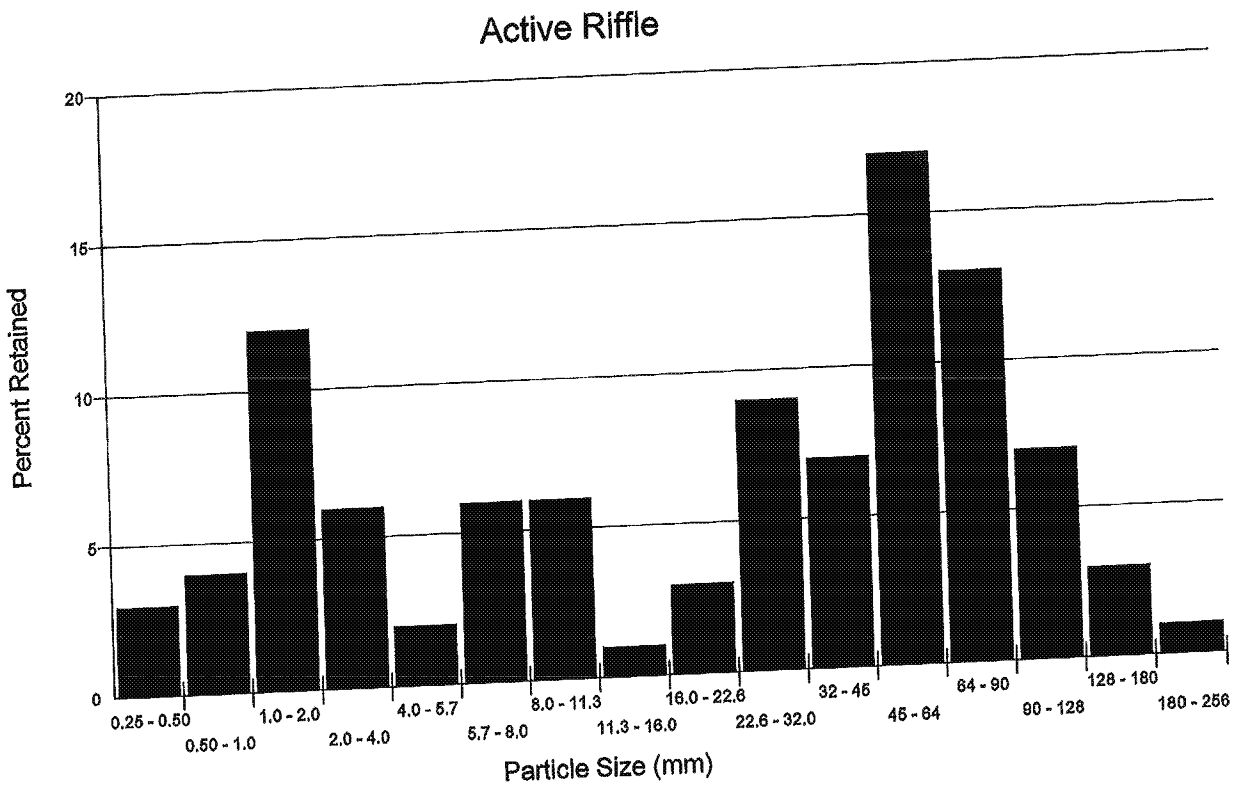
Attachment 4

Longitudinal Profile



Distance = 1035.98 Depth =-3.42 Slope =-.0033

Attachment 5


Active Riffle
Percent Retained
0
5
10
15
20
0.25 - 0.50
0.50 - 1.0
1.0 - 2.0
2.0 - 4.0
4.0 - 5.7
5.7 - 8.0
8.0 - 11.3
11.3 - 16.0
16.0 - 22.6
22.6 - 32.0
32 - 45
45 - 64
64 - 90
90 - 128
128 - 180
180 - 256
Particle Size (mm)

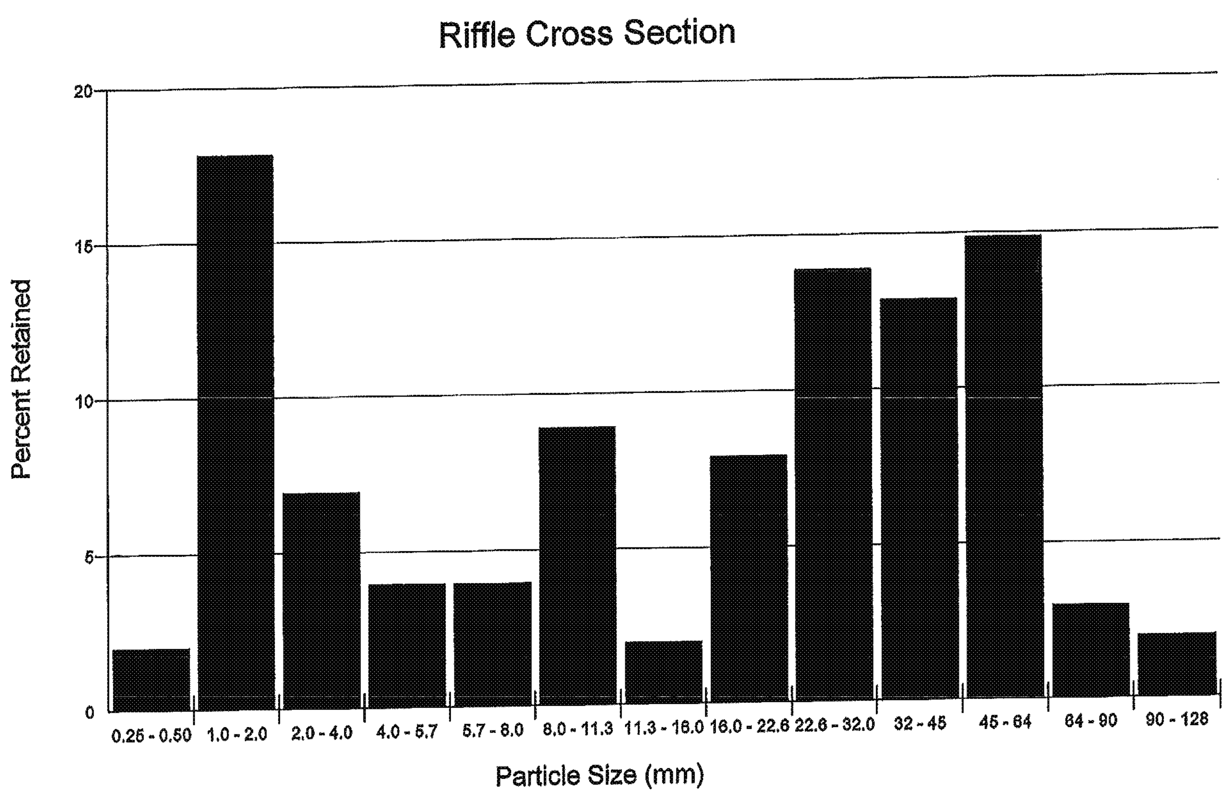
RIVERMORPH PARTICLE SUMMARY

River Name: Huron River Mill Race
Reach Name: Huron River below Argo Dam
Sample Name: Active Riffle
Survey Date: 06/21/2012

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	3	3.00	3.00
0.50 - 1.0	4	4.00	7.00
1.0 - 2.0	12	12.00	19.00
2.0 - 4.0	6	6.00	25.00
4.0 - 5.7	2	2.00	27.00
5.7 - 8.0	6	6.00	33.00
8.0 - 11.3	6	6.00	39.00
11.3 - 16.0	1	1.00	40.00
16.0 - 22.6	3	3.00	43.00
22.6 - 32.0	9	9.00	52.00
32 - 45	7	7.00	59.00
45 - 64	17	17.00	76.00
64 - 90	13	13.00	89.00
90 - 128	7	7.00	96.00
128 - 180	3	3.00	99.00
180 - 256	1	1.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	1.75
D35 (mm)	9.1
D50 (mm)	29.91
D84 (mm)	80
D95 (mm)	122.57
D100 (mm)	255.99
Silt/Clay (%)	0
Sand (%)	19
Gravel (%)	57
Cobble (%)	24
Boulder (%)	0
Bedrock (%)	0

Total Particles = 100.



Riffle Cross Section
Percent Retained
20
15
10
5
0
0.25 - 0.50
1.0 - 2.0
2.0 - 4.0
4.0 - 5.7
5.7 - 8.0
8.0 - 11.3
11.3 - 16.0
16.0 - 22.6
22.6 - 32.0
32 - 45
45 - 64
64 - 90
90 - 128
Particle Size (mm)

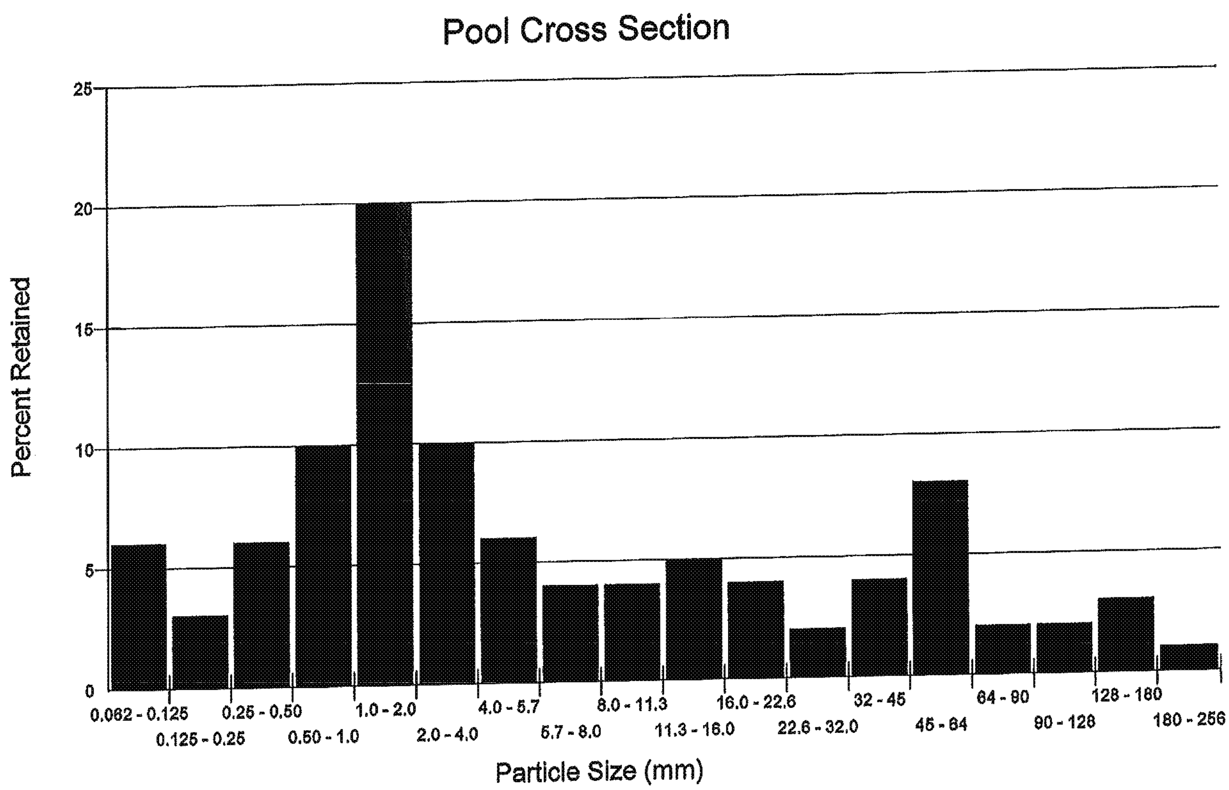
RIVERMORPH PARTICLE SUMMARY

River Name:	Huron River Mill Race
Reach Name:	Huron River below Argo Dam
Sample Name:	Riffle Cross Section
Survey Date:	06/28/2012

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	0	0.00	0.00
0.125 - 0.25	0	0.00	0.00
0.25 - 0.50	2	1.98	1.98
0.50 - 1.0	0	0.00	1.98
1.0 - 2.0	18	17.82	19.80
2.0 - 4.0	7	6.93	26.73
4.0 - 5.7	4	3.96	30.69
5.7 - 8.0	4	3.96	34.65
8.0 - 11.3	9	8.91	43.56
11.3 - 16.0	2	1.98	45.54
16.0 - 22.6	8	7.92	53.47
22.6 - 32.0	14	13.86	67.33
32 - 45	13	12.87	80.20
45 - 64	15	14.85	95.05
64 - 90	3	2.97	98.02
90 - 128	2	1.98	100.00
128 - 180	0	0.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	1.79
D35 (mm)	8.13
D50 (mm)	19.71
D84 (mm)	49.86
D95 (mm)	63.94
D100 (mm)	128
Silt/Clay (%)	0
Sand (%)	19.8
Gravel (%)	75.25
Cobble (%)	4.95
Boulder (%)	0
Bedrock (%)	0

Total Particles = 101.


Pool Cross Section
Percent Retained
25
20
15
10
5
0
0.062 - 0.125
0.125 - 0.25
0.25 - 0.50
0.50 - 1.0
1.0 - 2.0
2.0 - 4.0
4.0 - 5.7
5.7 - 8.0
8.0 - 11.3
11.3 - 16.0
16.0 - 22.6
22.6 - 32.0
32 - 45
45 - 64
64 - 90
90 - 128
128 - 180
180 - 256
Particle Size (mm)

RIVERMORPH PARTICLE SUMMARY

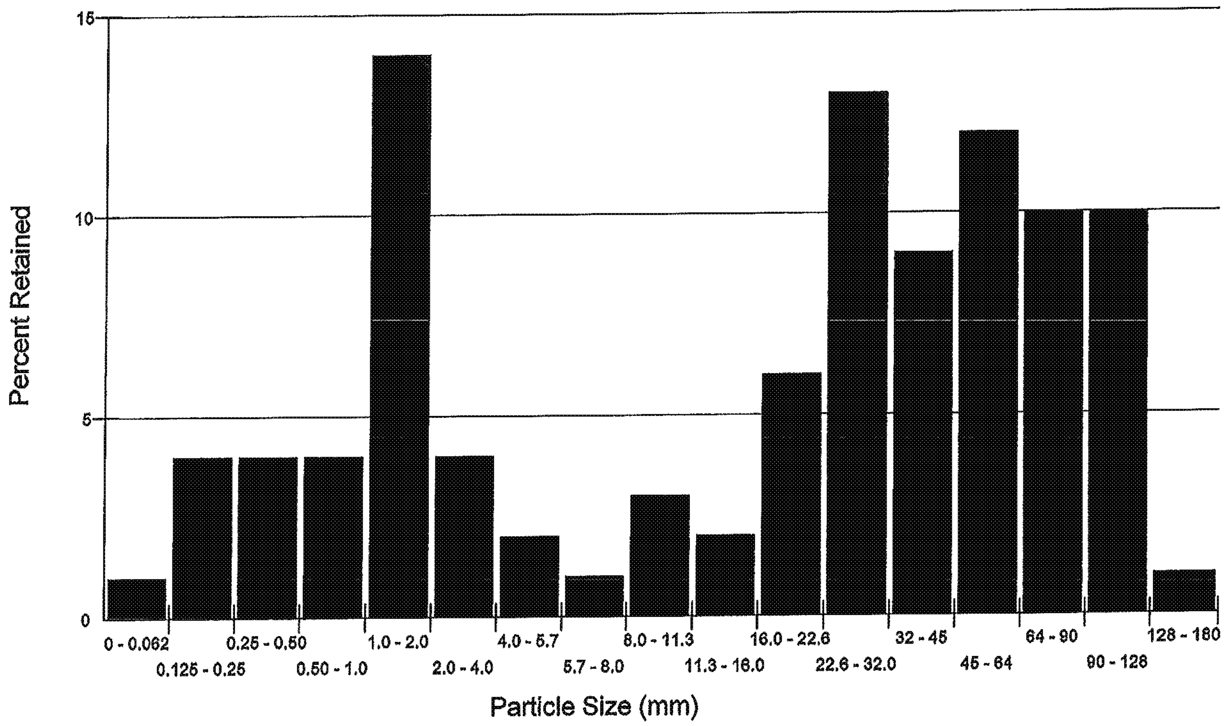
River Name: Huron River Mill Race
Reach Name: Huron River below Argo Dam
Sample Name: Pool Cross Section
Survey Date: 06/28/2012

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	0	0.00	0.00
0.062 - 0.125	6	6.00	6.00
0.125 - 0.25	3	3.00	9.00
0.25 - 0.50	6	6.00	15.00
0.50 - 1.0	10	10.00	25.00
1.0 - 2.0	20	20.00	45.00
2.0 - 4.0	10	10.00	55.00
4.0 - 5.7	6	6.00	61.00
5.7 - 8.0	4	4.00	65.00
8.0 - 11.3	4	4.00	69.00
11.3 - 16.0	5	5.00	74.00
16.0 - 22.6	4	4.00	78.00
22.6 - 32.0	2	2.00	80.00
32 - 45	4	4.00	84.00
45 - 64	8	8.00	92.00
64 - 90	2	2.00	94.00
90 - 128	2	2.00	96.00
128 - 180	3	3.00	99.00
180 - 256	1	1.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	0.55
D35 (mm)	1.5
D50 (mm)	3
D84 (mm)	45
D95 (mm)	109
D100 (mm)	255.99
Silt/Clay (%)	0
Sand (%)	45
Gravel (%)	47
Cobble (%)	8
Boulder (%)	0
Bedrock (%)	0

Total Particles = 100.

Reach to Broadway



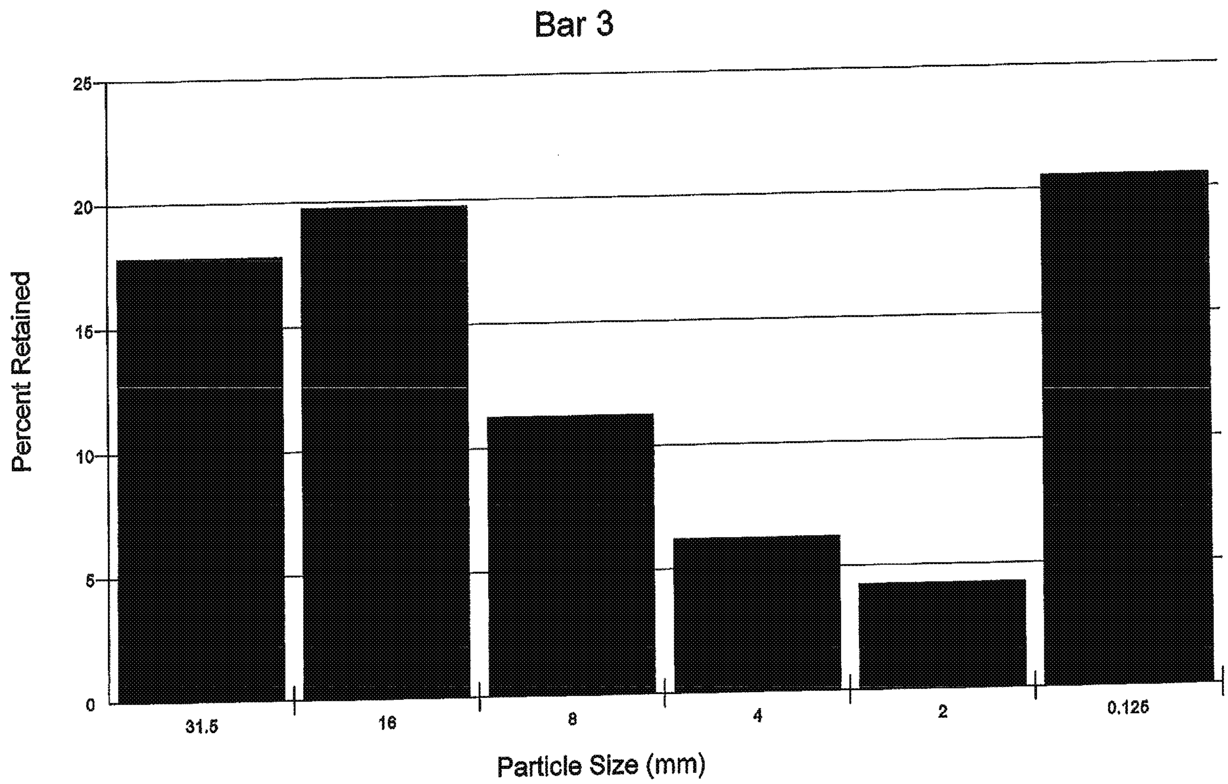
RIVERMORPH PARTICLE SUMMARY

River Name: Huron River Mill Race
Reach Name: Huron River below Argo Dam
Sample Name: Reach to Broadway
Survey Date: 06/28/2012

Size (mm)	TOT #	ITEM %	CUM %
0 - 0.062	1	1.00	1.00
0.062 - 0.125	0	0.00	1.00
0.125 - 0.25	4	4.00	5.00
0.25 - 0.50	4	4.00	9.00
0.50 - 1.0	4	4.00	13.00
1.0 - 2.0	14	14.00	27.00
2.0 - 4.0	4	4.00	31.00
4.0 - 5.7	2	2.00	33.00
5.7 - 8.0	1	1.00	34.00
8.0 - 11.3	3	3.00	37.00
11.3 - 16.0	2	2.00	39.00
16.0 - 22.6	6	6.00	45.00
22.6 - 32.0	13	13.00	58.00
32 - 45	9	9.00	67.00
45 - 64	12	12.00	79.00
64 - 90	10	10.00	89.00
90 - 128	10	10.00	99.00
128 - 180	1	1.00	100.00
180 - 256	0	0.00	100.00
256 - 362	0	0.00	100.00
362 - 512	0	0.00	100.00
512 - 1024	0	0.00	100.00
1024 - 2048	0	0.00	100.00
Bedrock	0	0.00	100.00

D16 (mm)	1.21
D35 (mm)	9.1
D50 (mm)	26.22
D84 (mm)	77
D95 (mm)	112.8
D100 (mm)	179.99
Silt/Clay (%)	1
Sand (%)	26
Gravel (%)	52
Cobble (%)	21
Boulder (%)	0
Bedrock (%)	0

Total Particles = 100.


Bar 3
Percent Retained
0
5
10
15
20
25
31.5
16
8
4
2
0.125
Particle Size (mm)

RIVERMORPH PARTICLE SUMMARY

River Name:	Huron River Mill Race
Reach Name:	Huron River below Argo Dam
Sample Name:	Bar 3
Survey Date:	06/29/2012

SIEVE (mm)	NET WT
31.5	2.875
16	3.1875
8	1.8125
4	1
2	0.6875
0.125	3.3125
PAN	0

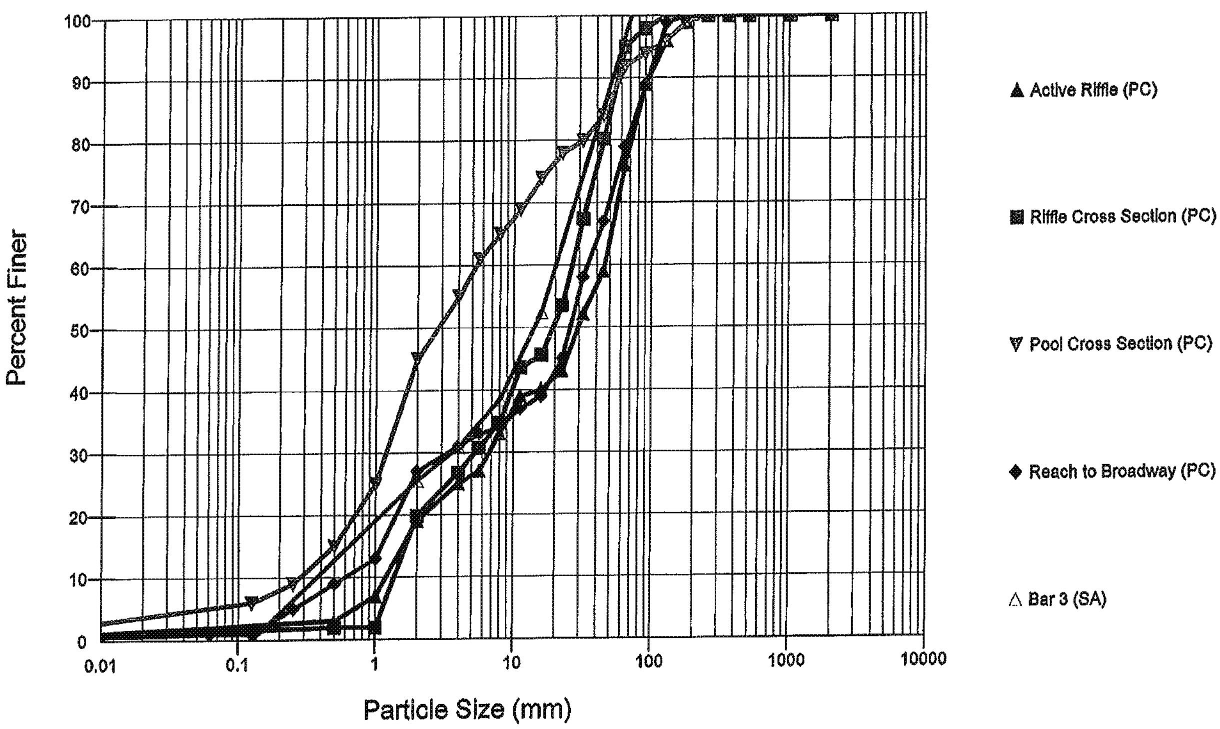
D16 (mm)	1.59
D35 (mm)	10.84
D50 (mm)	22.08
D84 (mm)	56.68
D95 (mm)	69.27
D100 (mm)	75
Silt/Clay (%)	0
Sand (%)	20.54
Gravel (%)	72.51
Cobble (%)	6.94
Boulder (%)	0
Bedrock (%)	0

Total Weight = 16.1250.

Largest Surface Particles:

	Size(mm)	Weight
Particle 1:	75	2
Particle 2:	60	1.25

Overlay of All Pebble Counts



Attachment 6

Worksheet 5-11. FLOWSED calculation of total annual sediment yield.

Stream: **Huron River Mill Race** Location: **Huron River below Argo Dam** Date: **06/29/2012**

Observers **Freiburger, Rathbun, Matousek, Reznick** Gage Station #: **04174500** Stream Type: **F 4** Valley Type: **VIII**

Equation type	Intercept	Coefficient	Exponent	Form (e.g., linear, non-linear, etc.)	Equation name
1. Bedload (dimensionless)	-0.0113	1.0139	2.1929	Non-Linear	Pagosa Springs Reference Curve
2. Suspended sediment (dimensionless)	0.0636	0.9326	2.4085	Non-Linear	Pagosa Springs Reference Curve
3. User-defined relations (bedload)					
4. User-defined relations (suspended sediment)					

Bankfull discharge (cfs)	Bankfull bedload (kg/s)	Bankfull suspended (mg/l)
1517.5	2.49	72.99

Notes:

From dimensioned flow-duration curve							From sediment rating curves				Calculate	Calculate sediment yield		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Flow exceedence	Daily mean discharge	Mid-ordinate	Time increment (percent)	Time increment (days)	Mid-ordinate streamflow	Dimension-less streamflow	Dimension-less suspended sediment discharge	Suspended sediment discharge	Dimension-less bedload discharge	Bedload	Time adjusted streamflow	Suspended sediment [(5)×(9)]	Bedload sediment [(5)×(11)]	Suspended + bedload [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
100.000	4.6													
90.000	121.4	95.00	10.00	36.50	63.0	0.04	4.9	0.8	0.0000	0.00	629.80	28.84	0.00	28.84
80.000	165.4	85.00	10.00	36.50	143.4	0.09	4.9	1.9	0.0000	0.00	1434.10	68.98	0.00	68.98
70.000	212.5	75.00	10.00	36.50	188.9	0.12	5.2	2.6	0.0095	0.00	1889.30	94.90	0.00	94.90
60.000	274.7	65.00	10.00	36.50	243.6	0.16	5.6	3.6	0.0234	0.78	2435.60	131.40	28.47	159.87
50.000	343.0	55.00	10.00	36.50	308.8	0.20	6.1	5.1	0.0418	2.12	3088.10	185.78	77.38	263.16
40.000	427.9	45.00	10.00	36.50	385.4	0.25	7.3	7.4	0.0870	4.19	3854.40	271.56	152.94	424.50
30.000	537.2	35.00	10.00	36.50	482.6	0.32	9.1	11.7	0.1522	7.65	4825.70	425.59	279.23	704.82
20.000	682.9	25.00	10.00	36.50	610.0	0.40	12.2	20.1	0.2653	13.56	6100.40	734.75	494.94	1229.69
10.000	951.5	15.00	10.00	36.50	817.2	0.54	20.2	44.1	0.5301	26.87	8171.70	1608.19	980.75	2588.94
5.000	1247.4	7.50	5.00	18.25	1099.4	0.72	36.2	106.8	1.0314	52.57	5497.15	1948.74	959.40	2908.14
4.000	1336.9	4.50	1.00	3.65	1292.2	0.85	51.1	177.4	1.4796	75.43	1292.15	647.66	275.32	922.98
3.000	1465.9	3.50	1.00	3.65	1401.4	0.92	61.0	230.2	1.7694	90.37	1401.41	840.27	329.85	1170.12
											Annual totals:	6987 (tons/yr)	3578 (tons/yr)	10565 (tons/yr)

Worksheet 5-12a. Bedload and suspended sand bed-material load transport prediction for the upstream reach, using the POWERSED model.

Stream: **Huron River Mill Race, Huron River below Argo Da** Location: Date: **06/29/12**

Observers: **Freiburger, Rathbun, Matousek, Reznick** Stream Type: **F 4** Valley Type: **VIII** Gage Station #: **04174500**

Flow-duration curve		Calculate	Hydraulic geometry				Measure	Calculate									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport [(13)×(14)]	Time adjusted suspended sand transport [(13)×(15)]	Time adjusted total transport [(16)+(17)]
(%)	(cfs)	(cfs)	(ft²)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft²)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.000	4.55									0.00			0.00	0.00		0.00	
90.000	121.40	62.98	43.80	83.92	0.52	1.44	0.0025	0.08	9.82	0.12	10.000	36.50	0.00	0.79	0.00	28.84	28.84
80.000	165.41	143.41	73.23	88.20	0.83	1.95	0.0025	0.13	22.37	0.25	10.000	36.50	0.00	1.89	0.00	68.98	68.98
70.000	212.45	188.93	87.42	90.62	0.96	2.16	0.0025	0.15	29.47	0.33	10.000	36.50	0.00	2.60	0.00	94.90	94.90
60.000	274.67	243.56	102.34	91.77	1.12	2.38	0.0025	0.17	38.00	0.41	10.000	36.50	0.78	3.60	28.47	131.40	159.87
50.000	342.95	308.81	118.51	92.68	1.28	2.60	0.0025	0.20	48.17	0.52	10.000	36.50	2.12	5.09	77.38	185.78	263.16
40.000	427.94	385.44	136.07	93.78	1.45	2.83	0.0025	0.22	60.13	0.64	10.000	36.50	4.19	7.44	152.94	271.56	424.50
30.000	537.20	482.57	156.63	95.08	1.65	3.08	0.0025	0.26	75.28	0.79	10.000	36.50	7.65	11.66	279.23	425.59	704.82
20.000	682.88	610.04	181.56	96.66	1.88	3.36	0.0025	0.29	95.17	0.98	10.000	36.50	13.56	20.13	494.94	734.75	1229.69
10.000	951.47	817.17	218.74	99.21	2.20	3.74	0.0025	0.34	127.48	1.28	10.000	36.50	26.87	44.06	980.75	1608.19	2588.94
5.000	1247.38	1099.43	263.24	100.79	2.61	4.18	0.0025	0.40	171.51	1.70	5.000	18.25	52.57	106.78	959.40	1948.74	2908.14
4.000	1336.92	1292.15	291.09	101.52	2.87	4.44	0.0025	0.44	201.58	1.99	1.000	3.65	75.43	177.44	275.32	647.66	922.98
3.000	1465.90	1401.41	306.19	101.92	3.00	4.58	0.0025	0.46	218.62	2.15	1.000	3.65	90.37	223.55	329.85	815.96	1145.81
2.000	1655.59	1560.74					0.0025			0.00			0.00	0.00		0.00	
1.500	1775.47	1715.53					0.0025			0.00			0.00	0.00		0.00	
1.000	1975.79	1875.63					0.0025			0.00			0.00	0.00		0.00	
0.900	2034.97	2005.38					0.0025			0.00			0.00	0.00		0.00	
0.800	2115.39	2075.18					0.0025			0.00			0.00	0.00		0.00	
0.700	2194.30	2154.85					0.0025			0.00			0.00	0.00		0.00	
0.600	2285.36	2239.83					0.0025			0.00			0.00	0.00		0.00	
0.500	2394.61	2339.99					0.0025			0.00			0.00	0.00		0.00	
0.250	2802.82	2598.72					0.0025			0.00			0.00	0.00		0.00	
0.100	3321.81	3062.32					0.0025			0.00			0.00	0.00		0.00	
0.050	3651.11	3486.46					0.0025			0.00			0.00	0.00		0.00	
0.010	4678.45	4164.78					0.0025			0.00			0.00	0.00		0.00	
0.005	5157.98	4918.22					0.0025			0.00			0.00	0.00		0.00	
0.001	5827.20	5492.59					0.0025			0.00			0.00	0.00		0.00	
										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					3578.3	6962.4	10540.6

Worksheet 5-12b. Bedload and suspended sand bed-material load transport prediction for the potentially impaired reach, using the POWERSED model.

Stream: **Huron River Mill Race, Huron River below Argo Dan** Location: **near cross section 2354.5** Date: **06/29/12**

Observers: **Freiburger, Rathbun, Matousek, Reznick** Stream Type: **F 4** Valley Type: **VIII** Gage Station #: **04174500**

Flow-duration curve		Calculate	Hydraulic geometry				Measure	Calculate									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Percentage of time	Daily mean discharge	Mid-ordinate stream-flow	Area	Width	Depth	Velocity	Slope	Shear stress	Stream power	Unit power	Time increment	Time increment	Daily mean bedload transport	Daily mean suspended sand transport	Time adjusted bedload transport [(13)×(14)]	Time adjusted suspended sand transport [(13)×(15)]	Time adjusted total transport [(16)+(17)]
(%)	(cfs)	(cfs)	(ft^2)	(ft)	(ft)	(ft/s)	(ft/ft)	(lb/ft^2)	(lb/s)	(lb/ft/s)	(%)	(days)	(tons/day)	(tons/day)	(tons)	(tons)	(tons)
100.000	4.54								0.00				0.00	0.00		0.00	
90.000	121.13	62.84	61.60	86.43	0.71	1.02	0.0015	0.07	5.88	0.07	10.000	36.50	0.00	0.78	0.00	28.47	28.47
80.000	165.04	143.08	103.54	91.83	1.13	1.38	0.0015	0.10	13.39	0.15	10.000	36.50	0.00	1.82	0.00	66.43	66.43
70.000	211.98	188.51	122.83	92.94	1.32	1.53	0.0015	0.12	17.64	0.19	10.000	36.50	0.00	2.43	0.00	88.70	88.70
60.000	274.06	243.02	143.89	94.27	1.53	1.69	0.0015	0.14	22.75	0.24	10.000	36.50	0.00	3.18	0.00	116.07	116.07
50.000	342.19	308.13	166.99	95.73	1.74	1.84	0.0015	0.16	28.84	0.30	10.000	36.50	0.00	4.17	0.00	152.20	152.20
40.000	426.99	384.59	192.15	97.40	1.97	2.00	0.0015	0.18	36.00	0.37	10.000	36.50	0.39	5.48	14.24	200.02	214.26
30.000	536.00	481.50	221.71	99.35	2.23	2.17	0.0015	0.21	45.07	0.45	10.000	36.50	1.25	7.41	45.63	270.47	316.10
20.000	681.36	608.68	256.68	100.62	2.55	2.37	0.0015	0.24	56.97	0.57	10.000	36.50	2.98	10.75	108.77	392.38	501.15
10.000	949.36	815.36	307.91	101.97	3.02	2.65	0.0015	0.28	76.32	0.75	10.000	36.50	6.74	18.65	246.01	680.72	926.73
5.000	1244.62	1096.99	370.45	103.24	3.59	2.96	0.0015	0.33	102.68	0.99	5.000	18.25	14.00	36.96	255.50	674.52	930.02
4.000	1333.95	1289.28	409.79	103.97	3.94	3.15	0.0015	0.36	120.68	1.16	1.000	3.65	21.56	58.73	78.69	214.36	293.05
3.000	1462.65	1398.30	431.18	104.36	4.13	3.24	0.0015	0.38	130.88	1.25	1.000	3.65	25.53	72.45	93.18	264.44	357.62
2.000	1651.92	1557.29					0.0015		0.00				0.00	0.00		0.00	
1.500	1771.53	1711.72					0.0015		0.00				0.00	0.00		0.00	
1.000	1971.40	1871.47					0.0015		0.00				0.00	0.00		0.00	
0.900	2030.45	2000.93					0.0015		0.00				0.00	0.00		0.00	
0.800	2110.70	2070.57					0.0015		0.00				0.00	0.00		0.00	
0.700	2189.43	2150.06					0.0015		0.00				0.00	0.00		0.00	
0.600	2280.28	2234.86					0.0015		0.00				0.00	0.00		0.00	
0.500	2389.30	2334.79					0.0015		0.00				0.00	0.00		0.00	
0.250	2796.60	2592.95					0.0015		0.00				0.00	0.00		0.00	
0.100	3314.43	3055.51					0.0015		0.00				0.00	0.00		0.00	
0.050	3643.00	3478.72					0.0015		0.00				0.00	0.00		0.00	
0.010	4668.06	4155.53					0.0015		0.00				0.00	0.00		0.00	
0.005	5146.53	4907.30					0.0015		0.00				0.00	0.00		0.00	
0.001	5814.26	5480.40					0.0015		0.00				0.00	0.00		0.00	

Notes:

	(16)	(17)	(18)
Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	842.0	3148.8	3990.8
Upstream total annual sediment comparative reach (tons/yr) (WS 5-20a):	3578.0	6962.0	10540.0
Difference in sediment transport capacity (tons/yr) (+ or -):	-3505.6	-6739.2	-7391.2
Stability evaluation: Aggradation, Degradation or Stable:	**Aggrading**		

Attachment 7

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES
LANSING

RICK SNYDER
GOVERNOR

RODNEY A. STOKES
DIRECTOR

April 24, 2012

Mr. Brian Steglitz, P.E.
City of Ann Arbor
Water Treatment Plant
919 Sunset Road
Ann Arbor, Michigan 48103

Dear Mr. Steglitz:

SUBJECT: Irregular Flow Hydrograph and Middle Huron River Water Quality Report

A couple of issues have recently come to our attention that we thought were beneficial to share with you. You may already be aware of them however we wanted to pass them onto just in case you were not as they may relate to the development of the proposed Whitewater Park (WWP) in the Huron River below Argo Dam or current recreational uses.

An issue that still appears to be problematic in the Huron River, as recorded by the U.S. Geological Survey Gage (USGS) Number 04174500 downstream of Argo Dam, is an irregular flow hydrograph occurring on almost a daily basis and large fluctuations of discharge of hundreds of cubic feet per second (cfs) to over a thousand cfs in short time durations of an hour causing a substantial increase in stage of a foot or more. The most recent large fluctuation as recorded as "provisional data" from the USGS occurred on April 24, 2012 where there was a swing in discharge from 985 cfs to 284 cfs between 10:45 am and 11:45 am (see attachment 1).

As you may be aware unnatural flow swings have been a reoccurring problem in the stretch of the Huron River through Ann Arbor for a number of years (see attachment 2). Due to these problems and complaints from downstream hydro owners the Federal Energy Regulatory Commission (FERC) became involved in this issue several years ago. Since that time Mr. Sumedh Bahl, a representative of the City of Ann Arbor has been working with the Michigan Department of Natural Resources, the USGS and the FERC to attempt to address these flow issues and develop better rating curves and installation of equipment to better manage run-of river flows at the Barton Hydro Project (FERC Number3142) as required by the exemption issued May 4, 1982 and understand how tributary streams maybe contributing to the problem.

Based on the latest USGS gage data it appears as though erratic flows continue to be an issue in this stretch of the Huron River in which we need to collectively work together to address. As it has been in the past, our concern largely lies on the impacts that fluctuating flows have on the aquatic environment and over all stability of the stream. However, due to the large fluctuations of flow and stage in short periods of time we do have concerns for public safety for users in this stretch of the river.

It is our understanding that Mr. Bahl has moved onto another position and is no longer overseeing hydro operations for the City of Ann Arbor however; we will plan to follow up with the proper representative of the City of Ann Arbor to get an update on ongoing efforts to understand how and why flow irregularities are continuing.

Also, recently we came across a report developed by the Huron River Watershed Council (HRWC) that addresses water quality issues in the Huron River. The name of the report is *"Bacteria Reduction Implementation Plan For The Middle Huron River Watershed October 2011 — September 2016."* We believe the City of Ann Arbor is partners in this effort with the HRWC and that you may be aware of the document and its findings however thought we would pass onto you just in case you were not. The document may be of importance to the City of Ann Arbor in relation to the proposed development of the WWP in the main stem of the Huron River below Argo Dam and the Allen's Creek outfall.

Below are excerpts taken from pages 6, 7 and 9 of the document; "Geddes Pond, located on the Huron River in Washtenaw County, Michigan, is listed as an impaired waterbody on Michigan's Section 303(d) list (Impaired Waterbodies List) due to impairment of recreational uses by the presence of elevated levels of pathogens. The listed segment addresses approximately five miles of the Huron River located in the Ann Arbor area, from Geddes Dam at Dixboro Road upstream to Argo Dam (see the map in Appendix A). This segment is also the receiving water for Allens Creek (a tributary that was enclosed in the 1920s) Traver Creek, Millers Creek, Malletts Creek, and Swift Run Creek. Water sampling in this area has shown that Michigan Water Quality Standards (WQS) for *Escherichia coli (E. coli)* are not consistently being met in this waterbody or its tributaries."

"A two-mile segment of Allens Creek is listed as an impaired waterbody on the Section 303(d) list due to impairment of recreational uses by the presence of elevated *E. coli* pathogens, and was scheduled for Total Maximum Daily Load (TMDL) creation in 2004. Rather than embark on a separate TMDL process for this segment, the Allens Creek listing is being addressed through the Geddes Pond/Huron River *E. coli* TMDL. "

"Section 303(d) of the Federal Clean Water Act and the United States Environmental Protection Agency's (USEPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop TMDLs for waterbodies that are not meeting the WQS. The impaired designated use for Geddes Pond/Huron River at this location is total body contact recreation. Rule 100 of the Michigan WQS requires that this waterbody be protected for total body contact recreation from May 1 to October 31. The target levels for this designated use are the ambient *E. coli* standards established in Rule 62 of the WQS as follows:

R 323.1062 Microorganisms
Rule 62. (1) All waters of the state protected for total body contact recreation shall not contain more than 130 *Escherichia coli (E. coli)* per 100 milliliters, as a 30-day geometric mean. Compliance shall be based on the geometric mean of all individual

samples taken during 5 or more sampling events representatively spread over a 30-day period. Each sampling event shall consist of 3 or more samples taken at representative locations within a defined sampling area. At no time shall waters of the state protected for total body contact recreation contain more than a maximum of 300 *E. coli* per 100 milliliters.

Compliance shall be based on the geometric mean of 3 or more samples taken during the same sampling event at representative locations within a defined sampling area. The Michigan Department of Environmental Quality (DEQ) finalized the Geddes Pond/Huron River *E. coli* TMDL in August, 2001 (Appendix B). The TMDL was developed based in part on a support document written by Limno-Tech, Inc. (Appendix C). The support document contains background information about the listed waterbody, known water quality data, and source assessment. The TMDL was approved by the USEPA on September 17, 2001. The DEQ recommends that the targets of the TMDL be achieved within 10 years of the approval date, or August 2011."

We wanted to ensure that you were aware of the report in your efforts for developing recreational opportunities in this stretch of the Huron River.

If you have any questions please do not hesitate to contact us. Thank you.

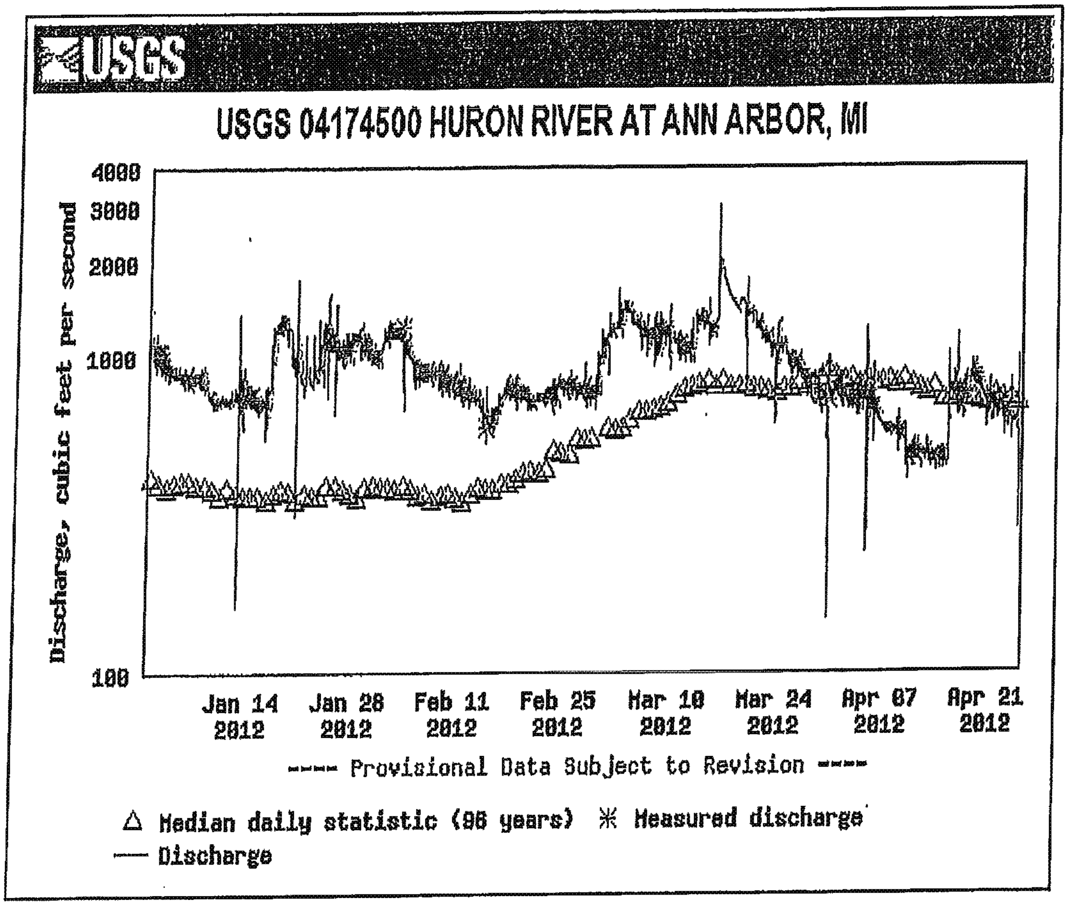
Sincerely,

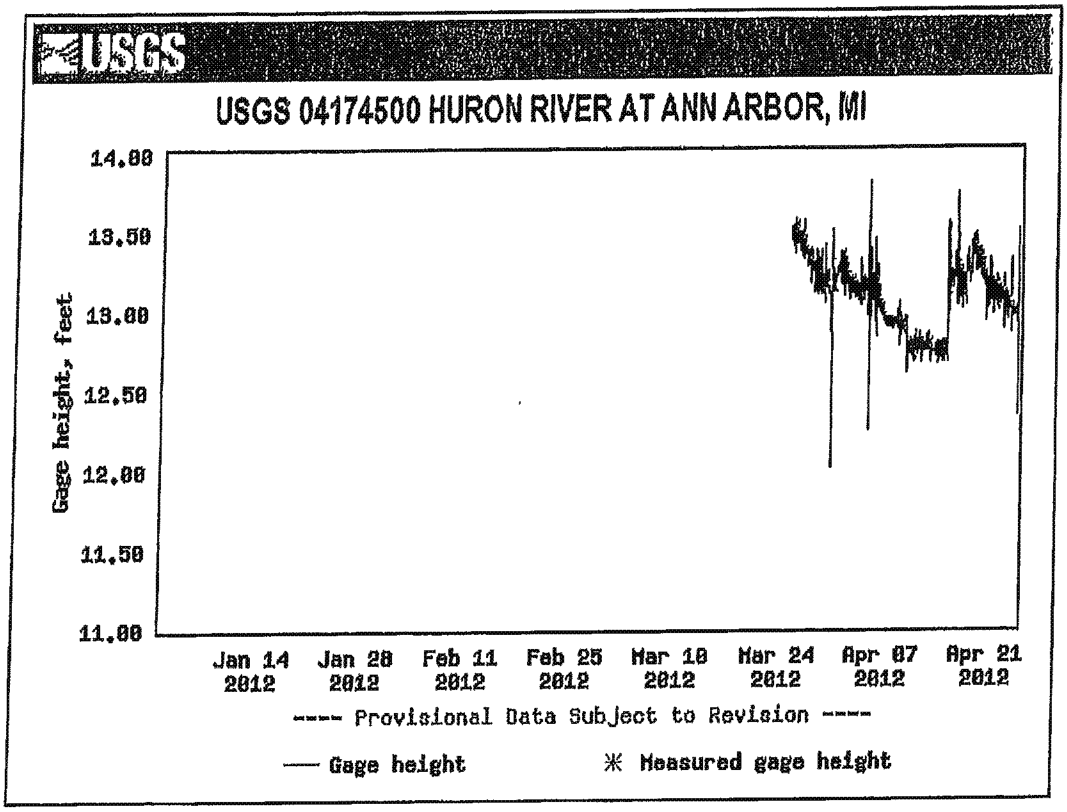
Chris Freiburger

Chris Freiburger
Fisheries Division
Habitat Management Unit

Attachments: USGS Records (2)
AnnArbor.com (3)

cc: Mr. Sumedh Bahl, City of Ann Arbor
Mr. Burr Fisher, USFWS
Mr. Ralph Reznick, DEQ
Mr. Todd Losee, DEQ
Mr. John Russell, DEQ
Mr. James Salle, DEQ
Mr. Jeff Braunscheidel, DNR
Ms. Liz Hay-Chmielewski, DNR


USGS
USGS 04174500 HURON RIVER AT ANN ARBOR, MI
Discharge, cubic feet per second
4000
3000
2000
1000
100
Jan 14 2012
Jan 28 2012
Feb 11 2012
Feb 25 2012
Mar 10 2012
Mar 24 2012
Apr 07 2012
Apr 21 2012
---- Provisional Data Subject to Revision ----
Median daily statistic (96 years)
Measured discharge
Discharge


USGS
USGS 04174500 HURON RIVER AT ANN ARBOR, MI
14.00
13.50
13.00
12.50
12.00
11.50
11.00
Gage height, feet
Jan 14 2012
Jan 28 2012
Feb 11 2012
Feb 25 2012
Mar 10 2012
Mar 24 2012
Apr 07 2012
Apr 21 2012
---- Provisional Data Subject to Revision ----
— Gage height
✳ Measured gage height

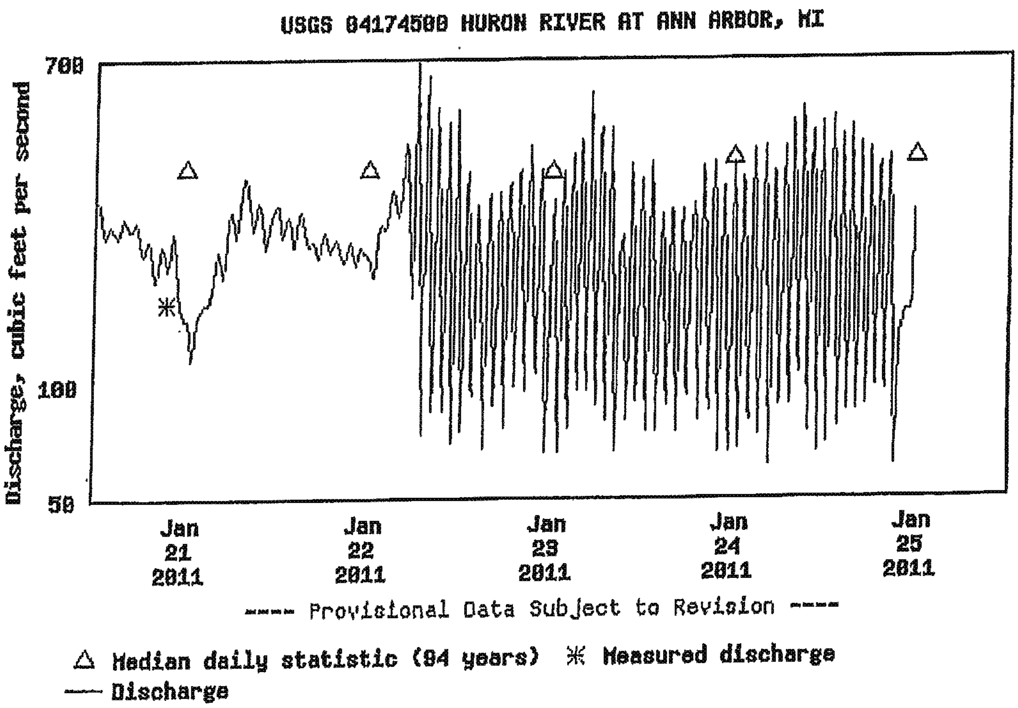
ANN ARBOR.com

By Edward Vielmetti

Argo Dam control system fails, causing Hur rise and fall quickly

Posted: Wed, Jan 26, 2011 : 10:54 a.m. Topics: Edward Vielmetti, News

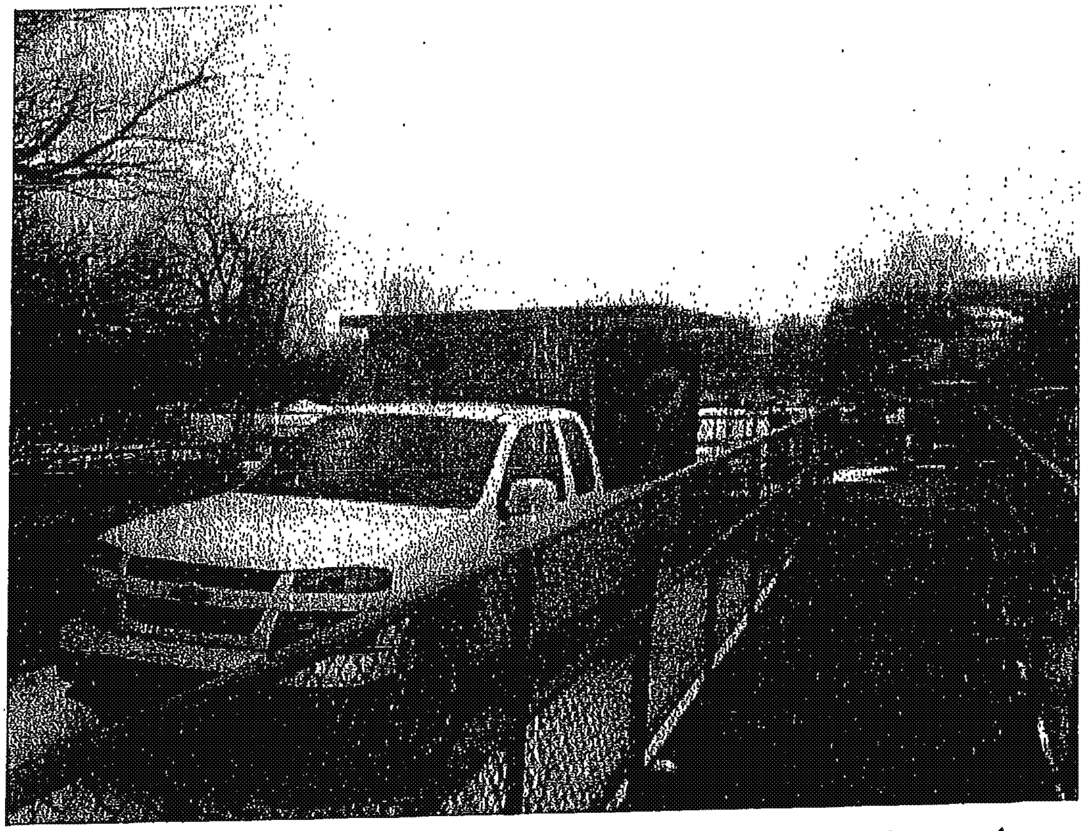
Water levels on the Huron River began fluctuating wildly late on Saturday, according to a stream gage monitored by the US Geological Survey. At peak flow levels, water discharge reached near 700 cubic feet per second, a high water mark with conditions that make it difficult and dangerous to wade in the river. At the low water mark, less than 70 cubic feet per second of water went down the river, leaving the bottom of the river mostly dry. **Tom Weaver** of the Michigan Water Science Center confirmed that the gauge was reading properly and was not malfunctioning.



Water levels on the Huron River fluctuated wildly downstream of the Argo Dam.

US Geological Survey

The gates on the dam were switched to manual control mid-day Tuesday in an attempt to even out the flows while the system was being worked on. Technicians replaced a failed transducer at the **Argo Dam** on Tuesday afternoon, according to **Molly Wade**, water treatment services manager at the City of Ann Arbor. The problems with the control system persisted overnight, and river levels are still in a state of rapid flux as of Wednesday morning. A crew was on site this morning, working to diagnose and repair the system.



Work is underway on site at the Argo Dam Wednesday morning to determine and correct the cause of a control systems problem which has led to extreme water level variations downstream of the dam.

Edward Vielmetti | AnnArbor.com

A **transducer** is a pressure gauge used to measure water levels on **Argo Pond**. The transducer is placed in a **stilling well**, which draws water from the pond through intakes beneath the pond's surface. Signals from the transducer are sent to control systems at the dam which cause the gates on the dam to move, letting more or less water downstream in order to keep the pond at a constant level. If the transducer fails, or if the intake valves are blocked by debris, ice, or zebra mussels, the water level as measured at the dam will be incorrect.

The control systems on Argo Dam have failed before, with similar results. In April 2010, the river's flow went from 50 cubic feet per second to more than 1,000 cubic feet per second in a few hours. Rapid water rises cause anglers wading in the river to scramble for the banks, and rapid water drops leave canoeists beached on river bottom mud. The Huron River Watershed Council, led by executive director **Laura Rubin**, conducted public meetings last July to discuss river fluctuations.

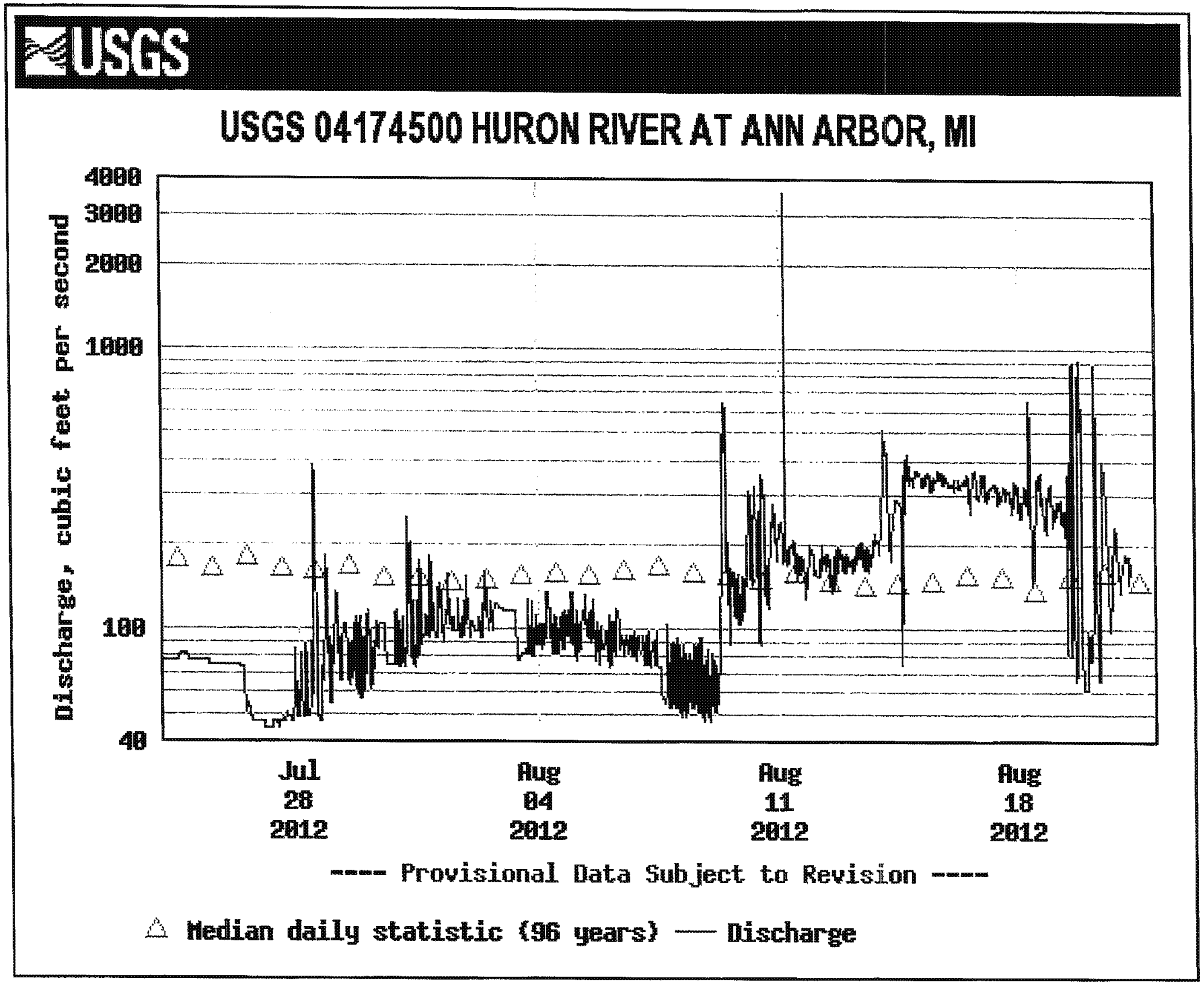
Aquatic biologist **Dave Fanslow** noted the poor flow management of the river in an electronic mail message on Tuesday to the watershed council. In a telephone interview, he described the impact of these extreme flow variations on the mayflies, caddis flies, and stoneflies that provide food for fish on the river.

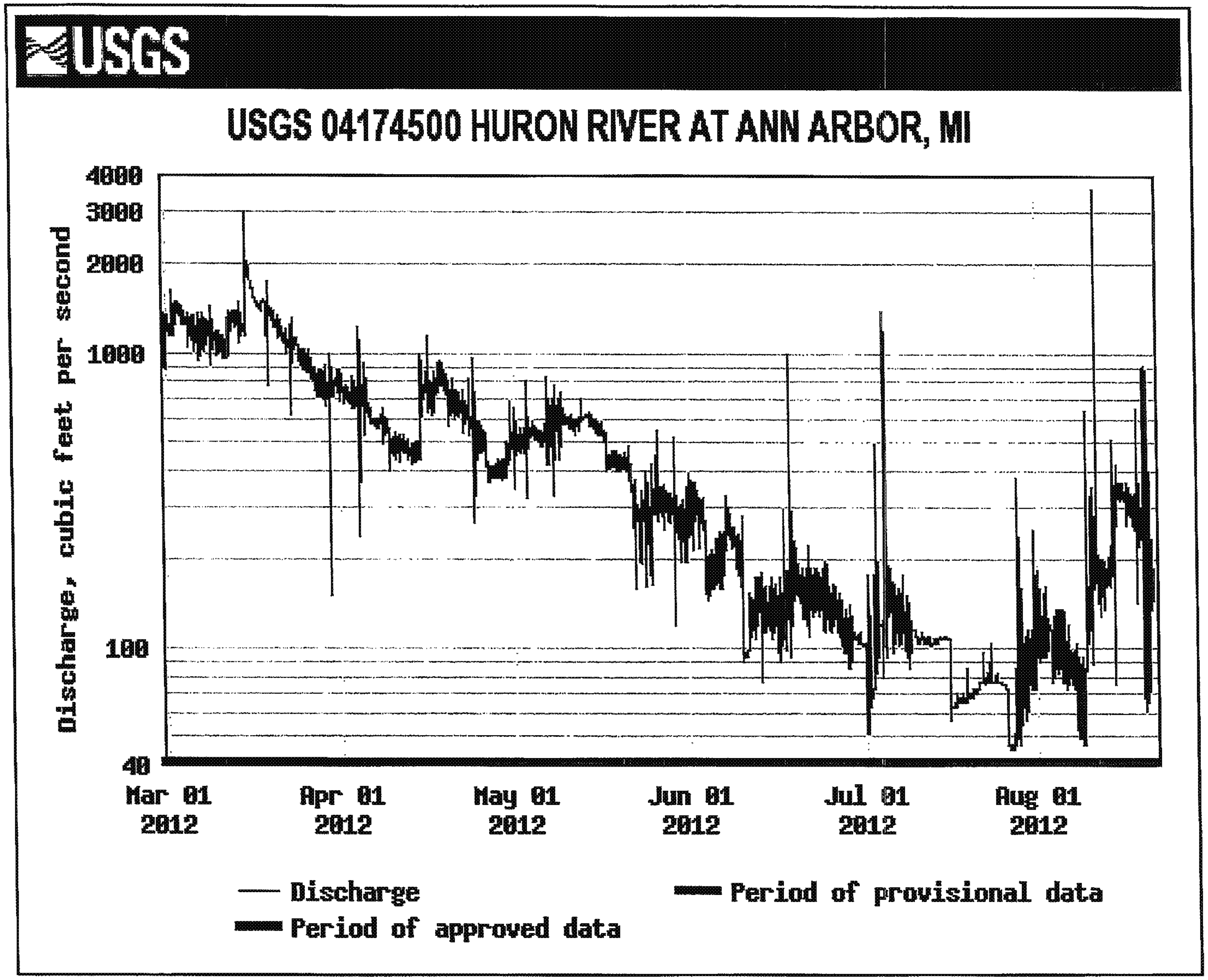
"The dam needs some tweaking if it's going to stay," said Fanslow, noting that these issues were "amplifying the environmental degradation" associated with dams.

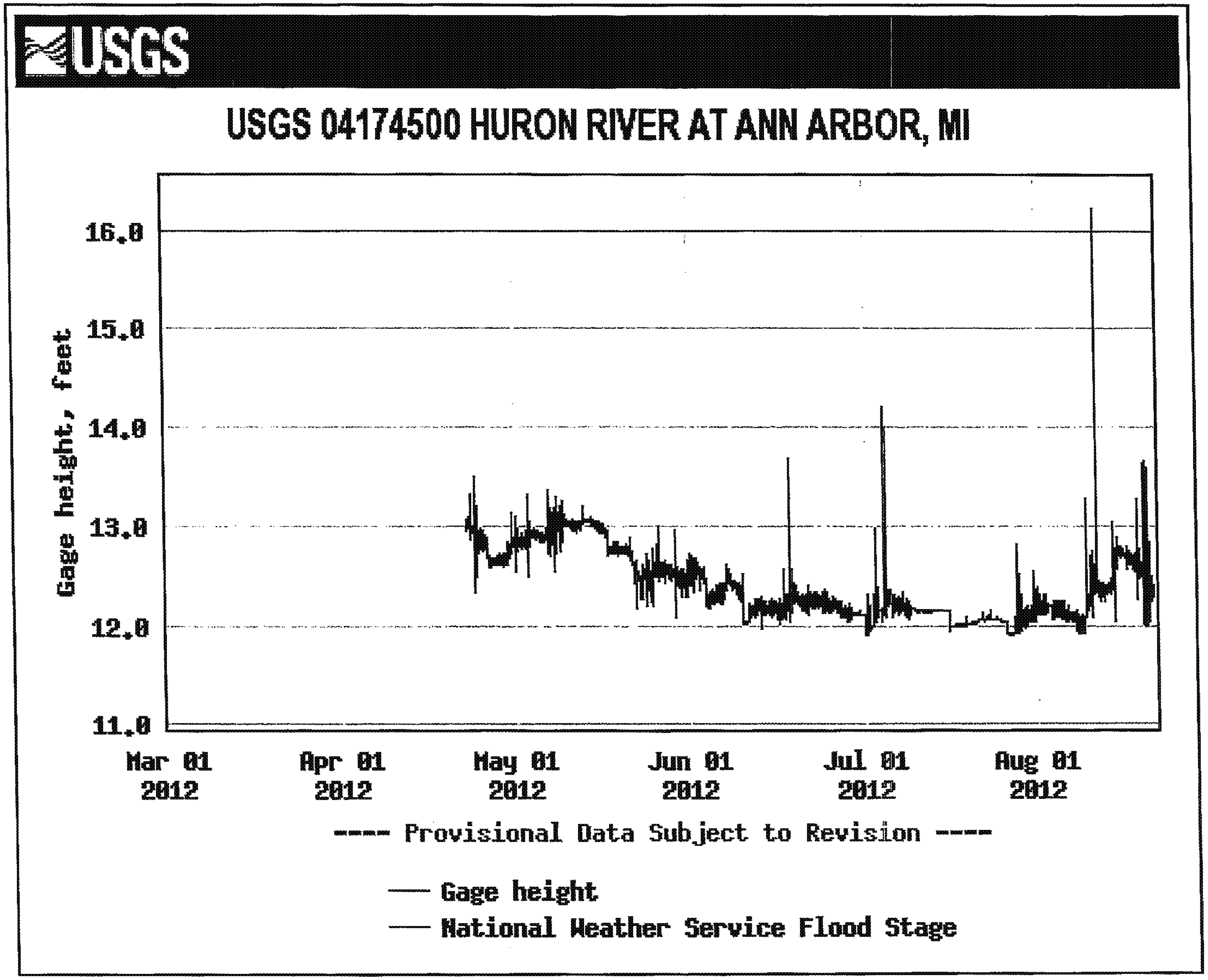
Edward Vielmetti writes about the Huron River for AnnArbor.com. Contact him at edwardvielmetti@annarbor.com.

Tags: Argo Dam, Argo Pond, Huron River, outdoors

Attachment 8


USGS
USGS 04174500 HURON RIVER AT ANN ARBOR, MI
Discharge, cubic feet per second
4000
3000
2000
1000
100
40
Jul 28 2012
Aug 04 2012
Aug 11 2012
Aug 18 2012
---- Provisional Data Subject to Revision ----
Median daily statistic (96 years)
Discharge


USGS
USGS 04174500 HURON RIVER AT ANN ARBOR, MI
Discharge, cubic feet per second
4000
3000
2000
1000
100
40
Mar 01 2012
Apr 01 2012
May 01 2012
Jun 01 2012
Jul 01 2012
Aug 01 2012
Discharge
Period of approved data
Period of provisional data


USGS
USGS 04174500 HURON RIVER AT ANN ARBOR, MI
Gage height, feet
16.0
15.0
14.0
13.0
12.0
11.0
Mar 01 2012
Apr 01 2012
May 01 2012
Jun 01 2012
Jul 01 2012
Aug 01 2012
---- Provisional Data Subject to Revision ----
— Gage height
— National Weather Service Flood Stage

Attachment 9

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES
LANSING

RICK SNYDER
GOVERNOR

KEITH CREAGH
DIRECTOR

July 31, 2012

Ms. Molly Wade
City of Ann Arbor
919 Sunset Road
Ann Arbor, Michigan 48103

Dear Ms. Wade:

SUBJECT: Flow releases through Argo Dam and the Argo Headrace

The Department of Natural Resources (DNR) received a number of complaints from the public last week concerning low flows and the dewatered condition of the Huron River bed below Argo Dam. As you maybe aware an individual posted a YouTube video, which can be found at http://www.youtube.com/watch?v=6J7YkaLwHQ8, documenting flow conditions on Thursday, July 26, 2012.

Based on an e-mail that I was forwarded from Mr. James Sallee, Department of Environmental Quality (DEQ), I understand he inquired last week about the flow situation at Argo Dam and was told by the City that a stop log had been installed to temporarily reduce the flows to the headrace. I was out of the office last week and wanted to follow up with the City to determine if any actions had been taken to resolve the flow imbalance between the headrace and the Huron River directly downstream of Argo Dam. I also inquired if the City had any plan(s) or operational guidance document(s) to assist staff operating the facility to determine the appropriate flow split between releases at Argo Dam into the river channel and the headrace. I had the opportunity to speak with Mr. Brian Steglitz from your office yesterday to obtain a better understanding of the above issues from the City's perspective.

It is my understanding, from speaking with Mr. Steglitz, that Argo Dam is operated by the City as a run-of-river project and flows are split between the headrace and Argo Dam. Specifically, if the flow into Argo Impoundment is 85 cubic feet per second (cfs) or less, that an additional stop log will be placed in the headrace control structure to reduce flows through the headrace by approximately 30 cfs, as was done on Thursday, July 26. The flow in the headrace would be reduced; however approximately 30 cfs would still continue to be released through the headrace. Under these conditions since a minimum of 60 cfs is not being released down the headrace the City would then make the determination whether or not to close the Cascades for public recreation. Once flows received in the Argo Impoundment are greater than 85 cfs the City's protocol is to divert 60 cfs through the headrace and the remainder through Argo Dam.

The DNR understands and appreciates that the current low flow condition in the Huron River makes operations of dams and associated structures challenging, however we have serious concerns about the impacts the current operation of the Argo Dam is having on the stretch of the Huron River between the Argo Dam and the outlet of the headrace, particularly now with the extremely low water levels and higher than normal air temperatures. This is not only a stressful time for aquatic life in river systems that are free flowing but may become even more stressful in managed systems such as the Huron River in Ann Arbor. To this effect the DNR sent out a press release on July 23, 2012 titled, "*Extreme heat and drought causing fish kills*" (see attached).

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Over the course of July, DNR staff has been spent considerable time in this stretch of the Huron River in order to evaluate the permit application for the proposed whitewater park structures in the main river channel below Argo (DEQ No. 12-81-0027-P). During this time we have observed, measured and calculated flows through the Argo Dam and compared them to that of the USGS Wall Street Gage (USGS 04174500) to derive total discharge then determine discharge through the headrace by using a mass balance equation. After talking with Mr. Steglitz yesterday he confirmed what was measured in the field which means that at times the headrace will have greater flow than the Huron River below Argo Dam. In essence, the flows in the headrace take greater priority than Huron River between Argo Dam and the headrace outfall.

Based on my discussions with Mr. Steglitz it does not appear that at the time the permit for the headrace modification was issued there was any plan or operational guidance regarding how flows would be managed between the Huron River proper and the headrace channel. Mr. Steglitz indicated that the City would continue to operate the project as they have until the state has other recommendations.

The DNR has a number of concerns regarding the routing of flow through the project. These include the un-natural flow hydrograph as recorded at the USGS Wall Street Gage. These abnormalities appear to be a function of rapid gate adjustment, rapid change in flow to the downstream river as adjustments are made in to the gates to manage impoundment levels which lead to significant increases and decreases in flows over short periods of time, and placing or removing stop logs into the headwater control without ramping flows results in large discharge fluctuation as was experienced last week when the stop log was put in place in the headrace(see attached USGS Hydrograph). The rating curves for the gates at Argo Dam need to be verified to make sure the gate rating table is accurate and represents actual flows. I found there were some discrepancies between DNR calculations and those shared with us that were derived from the gate rating table. On other projects we have found that the rating tables may be fairly accurate but often time's debris is caught in the bottom draw gates thereby reducing flows, this may be a situation at Argo Dam.

There are a number of issues to be discussed which will take some time for each of us to obtain a better understanding of how to move forward to develop an operational plan that protects fish, wildlife and recreational use of the Huron River. The DNR does not support or concur that the current plan that the City is utilizing provides adequate protection of the aquatic resources of the Huron River.

Due to current low flow conditions in the river and the need to react quickly to reduce any further resource damages and maintain established recreational use below Argo Dam we would request that the City release a minimum flow of 100 cfs or inflow into the impoundment, whichever is less through the Argo Project into the Huron River in order to prevent the loss of, or damage to, fish and wildlife resources. During these low flow conditions in order to sustain fish and wildlife resources and maintain water quality in the headrace a discharge of 5 cfs of the minimum flow should be released into the headrace and the remainder passed through the Argo Dam. This 5 cfs release into the headrace could be obtained by modifying stop log boards, adding spacers between stop logs, a siphon tube, or other modification such that the flow will be assured in the headrace. It would need to be checked daily to remove any debris or other obstructions that may cause a reduction in the flow.

As I had mentioned above, since time is of the essence and currently there is not adequate time to conduct studies and enter into necessary discussion to resolve this issue immediately, the DNR is relying on documentation in the record to assist in determining an appropriate minimum release until an appropriate operational plan can be developed. The Order Granting Exemption from Licensing for a Small Hydroelectric Project of 5 Megawatts of Less, issued May 4, 1982 for the Barton Hydroelectric Project (No. 3142-007) requires a minimum flow of 100 cfs or inflow into the impoundment, whichever is less. Since the Argo Dam is located downstream of the Barton Hydroelectric Project and has an increased drainage area it is reasonable to assume that discharge at Argo would be the same or greater than at Barton. Therefore we believe this recommendation for a minimum flow at Argo is appropriate. Further at the time the City of Ann Arbor was exploring development of hydroelectric generation at its other dams on the Huron River the DNR was seeking a minimum flow of 100 cfs for each dam at that time. So in light of not having new or more detailed information and the necessity to react quickly we believe this is the best and most appropriate information available to justify the DNR's request.

This operational guidance should be put in place immediately thereby directing flows to the Huron River below Argo Dam reducing negative impacts to the aquatic resources below the dam and should remain in effect until there is adequate time for the City, DNR, DEQ and others to agree on an operational plan for the future.

We appreciate your consideration of the above matter and recognize that based on your current flow operation plan this may result in additional closures of the cascades, however the requested changes will reduce resource impacts to the Huron River below Argo Dam and maintain established recreational use. We would appreciate your prompt response to the matter. Please feel free to call me to discuss.

Sincerely,

Chris Freiburger

Chris Freiburger
Fisheries Division
Habitat Management Unit
Environmental Assessment Sub-Unit
517-373-6644

Attachments: DNR Press Release
USGS Gage Data

cc: Mr. Brian Steglitz, City of Ann Arbor
Ms. Elizabeth Riggs, Huron River Watershed Council
Mr. James Bettaso, USFWS
Ms. Andrea Ania, USFWS
Mr. James Sallee, DEQ
Mr. Todd Losee, DEQ
Ms. Amy Lounds, DEQ
Ms. Bethany Matousek, DEQ
Mr. Jon Russell, DEQ
Ms. Liz Hay-Chmielewski, DNR
Mr. Todd Kalish, DNR
Mr. Jeff Braunscheidel, DNR
Mr. Randy Claramunt, DNR
Mr. Gary Whelan, DNR
Mr. Kyle Kruger, DNR

FOR IMMEDIATE RELEASE
July 23, 2012

Contact: Gary Whelan, 517-373-6948; Martha Wolgamood, 269-668-2696 or Ed Golder, 517-335-3014

Extreme heat and drought causing fish kills

There have been numerous fish kills recently reported from around the state, and staff from the Michigan Department of Natural Resources' Fisheries Division is tracking and monitoring these events.

"We appreciate the public letting us know where they are seeing unusual fish kill events," said Jim Dexter, Fisheries Division chief. "This can be done by emailing reports to DNR-FISH-Report-Fish-Kills@michigan.gov."

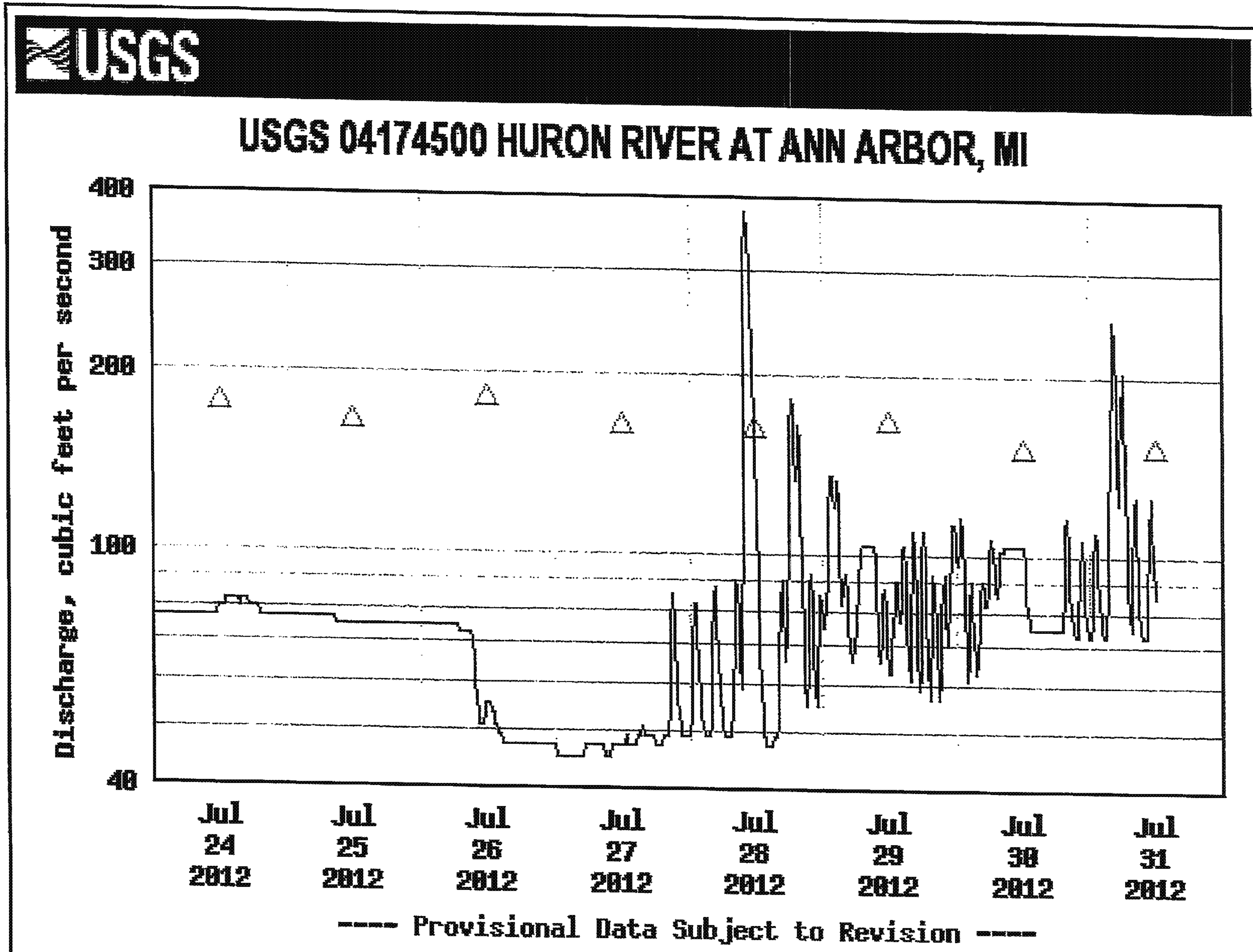
The combination of very high water temperatures and drought flow conditions have made conditions very stressful for fish and, in many cases, these conditions are beyond lethal temperatures for fish. Additionally, high water temperatures also often result in low oxygen values, particularly where there is a lot of vegetation.

"For example, water temperatures of nearly 90 degrees Fahrenheit were recorded in the lower Shiawassee River last week, which resulted in a small kill of northern pike as temperatures were beyond their physiological ability to handle these conditions," explained Gary Whelan, DNR fish production manager. "We expect to see more of these fish kills until there are major changes in this summer's weather."

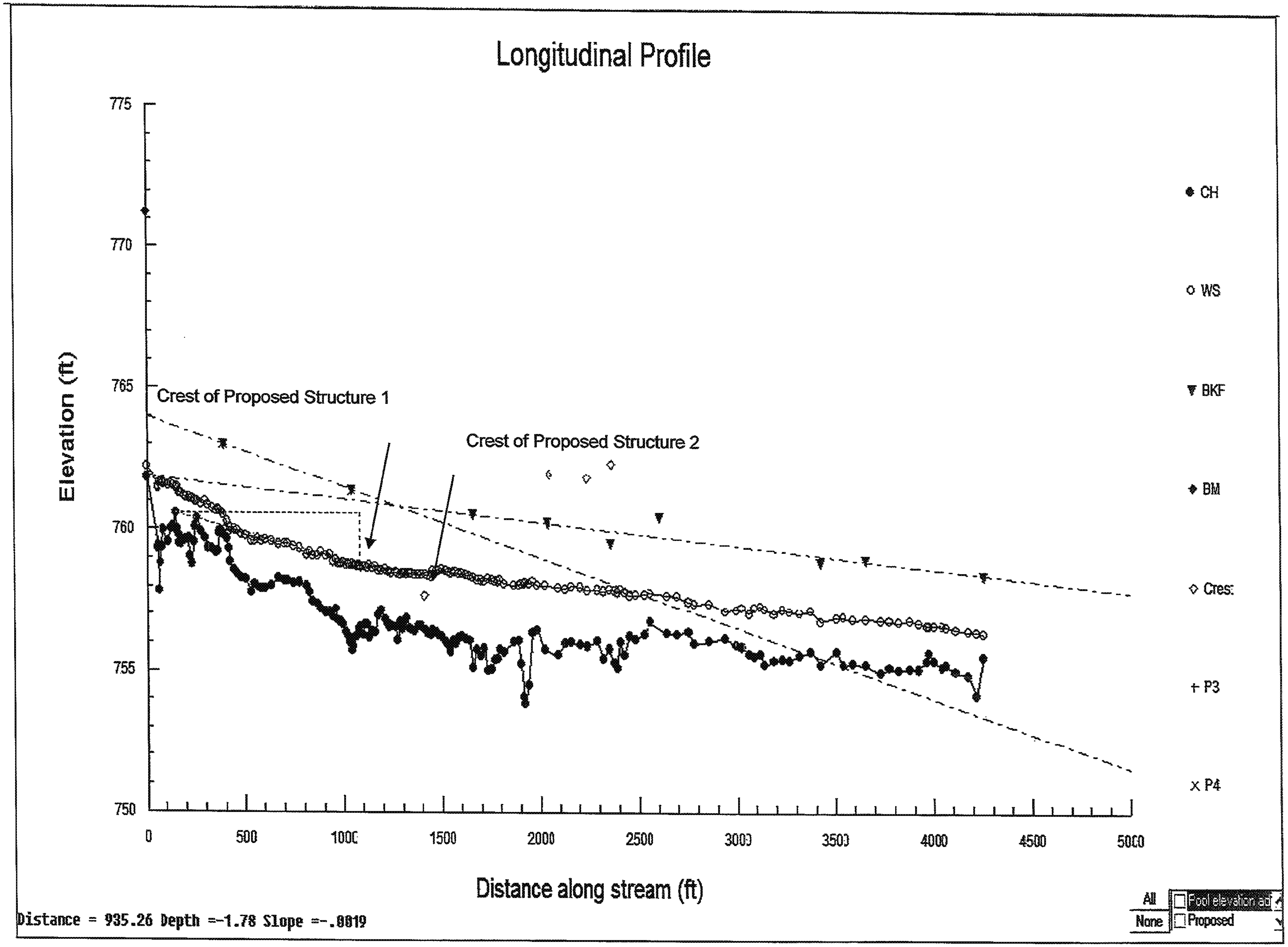
The overall fisheries effects of such events are often very local in nature and may not significantly change overall population numbers. However, population level effects are not known at this time and will take some time to fully evaluate.

"We recommend anglers be extra careful in handling and unhooking fish that are to be released to keep stress to a minimum. It is also best for our fish if anglers refrain from fishing during the hottest parts of the day and not keep fish to be released in live wells for very long," continued Whelan. "Fishing in the early morning period is least stressful for fish, as it has the coolest water temperatures."

For more information on fish kills in Michigan, visit www.michigan.gov/fishing. Anyone who suspects a fish kill is caused by non-natural causes is asked to please call the nearest DNR office or Michigan's Pollution Emergency Alert System at 1-800-292-4706.


USGS
USGS 04174500 HURON RIVER AT ANN ARBOR, MI
Discharge, cubic feet per second
400
300
200
100
40
Jul 24 2012
Jul 25 2012
Jul 26 2012
Jul 27 2012
Jul 28 2012
Jul 29 2012
Jul 30 2012
Jul 31 2012
---- Provisional Data Subject to Revision ----

Attachment 10



Longitudinal Profile
Elevation (ft)
Distance along stream (ft)
775
770
765
760
755
750
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Crest of Proposed Structure 1
Crest of Proposed Structure 2
CH
WS
BKF
BM
Crest
P3
P4
Distance = 935.26 Depth =-1.78 Slope =-.0019
All
None
Pool elevation ad
Proposed

Attachment 11

Rocks in the River, Part Three

Bill Hudson | 7/29/08

Back to the News Summaries

Read Part One

Back in 1994, when the Town of Pagosa Springs began work on the original restoration of the downtown San Juan River funded by a sizable "Fishing is Fun" grant, the actual placement of the boulders were the last step in a long process. The first part of the process — a step required by the federal government and the Colorado Division of Wildlife (DOW) before any rocks could be placed — involved securing easements in and along the river to assure that the public would be able to legally access the planned fishing enhancements.

According to a source close to the original "Fishing is Fun" project (who prefers not to be identified) the "Fishing is Fun" project was aimed at improved fishing opportunities in the downtown San Juan, so the federal and state governments wanted the Town to acquire a ten-foot-wide access easement above the high water mark, from all the property owners along the downtown San Juan. The Town spent just over $100,000 securing those easements in 1994. According to my source, the only property owner who did not grant the ten-foot fishing access easement was the Spring Inn — now the Springs Resort. The Town and their "Fishing is Fun" contractor, hydrologist Dave Rosgen, placed the fishing enhancements in places that generally offered easy fishing access from at least one side of the river.

I attempted to verify my source's easement information at the County Assessor's office, but discovered that the County Assessor does not usually record easements in their computer database, since easements generally have little or no impact on property values. At this point, I am not sure if the 1994 easements were ever recorded.

The fact remains, however, that the easements were a crucial part of the "Fishing is Fun" planning process, and were seen as important enough to justify a $100,000 investment.

Fast forward to December 2004, and a new $50,000 contract between Town Manager Mark Garcia and white water park designers Recreational Engineering and Planning (REP) of Boulder, Colorado. The contract specifies the design of a well-engineered white water park that essentially replaces the 1995 "Fishing is Fun" structures with new boating-friendly structures.

As Town Manager Garcia signs this contract, he has no permits for this project, he has no permission from the federal government or DOW to remove the grant-funded "Fishing is Fun" structures — and he has no easements for the new project. All the Town's existing easements were obtained through careful agreements that supported the "Fishing is Fun" structures — not a future white water park.

Garcia has also budgeted the project for materials and design only, depending totally on Wolf Creek Ski Area owner Davey Pitcher to donate all the heavy equipment and labor costs.

At last Thursday's work session between the Town and REP's Gary Lacy, it became quite evident that, three and a half years later, the Town still has no final permits, no final permission to remove the "Fishing is Fun" structures — and no easements. Yet the Town has paid Lacy nearly $84,000 for design work — and for help obtaining permits, permissions and easements.

During Thursday's meeting, several members of the public spoke from the audience, including a couple supporters of the white water park concept. Many of the comments from the audience, however, were critical of the way the Town and REP have handled the project — particularly, how the project could have come so far without any easements or permits in place, and without any clear idea who would be overseeing the entire project, now that the white water park's key proponent, former

Town Manager Mark Garcia, has resigned from the Town.

Springs Resort representative Bill Whittington, who attended the meeting with his daughter, resort owner Keely Whittington-Reyes, and resort pool designer Matt Mees, explained the reasons why the Springs Resort has withdrawn its support for the current white water park — even though Bill Whittington had originally helped with the construction of the Davey Wave in March 2005, only weeks after the Whittingtons purchased the Springs Resort.

"We were just new to town and we thought everybody loved everybody. The [new west bank rock work] looked fantastic, but then everything started unwinding... Kara Helige from the Corps had a big problem with grout being used in the river... the USGS guy was very hot and very directed about the loss of the gauging station, and offered to whip my ass... and I felt like there was obviously a gigantic problem. And I got a lot of phone calls about the fishing grant money that was already spent there; we got raked through the coals from those folks..."

Referring to documents he obtained from the Army Corps of Engineers, Whittington stated that the ACOE had never agreed with the Town that the existing "Fishing is Fun" structures needed replacement.

Whittington praised the existing structures at Thursday's meeting. "We spent the time, we spent the money, we did 12 years of study. It's not flooding anybody, it's doing a good job. We personally book many thousands of dollars worth of river rafting on that river — and we also see the kayakers using the [existing "W" weirs] all up and down the river. Why are we spending money — and why are we having these conversations — if what's out there is already working?

"I thought the reason the Town wanted to [reconstruct the river] was based on some grandiose reason, but when I researched what was going on and read the documents, I can't see why you want to change it. The fishing guys come to me and say, 'There's thirty people out there playing on that Wave; we can't fish there.' I helped you build [the Davey Wave,] I grant you that, but I watch the river eight, ten hours a day. There's no conflict between fishermen and boaters when the boaters are floating through — they wave, the fishermen wave — but when you put a stoppage in the river [like the Davey Wave] that's when you start creating a problem between boating and fishing."

Whittington implied that the resort might be willing to support a white water park located elsewhere in the river, by providing easements and even donating additional funding.

"You guys [at REP] have designed some very nice projects, I'm not debating that. But I think we can better utilize our money if we can keep what we've got and move [the white water park] to another area."

Lacy's associate at the Thursday meeting, Shane Sigle, affirmed that REP would be happy to redesign the project for a different location — at cost, of course — but suggested that a white water park would function better in a popular, accessible area of river like the stretch indicated in the present REP plans.

If only REP and the Town had the permissions needed to place it there.

The Councilors currently sitting on the Town Council are not all the same ones who have been funding REP's work for the past four years. Listening to the comments from the various Councilors during Thursday's meeting — and especially hearing the comments from the Springs Resort representatives — it appears doubtful that the downtown water park, as currently sketched, will be completed under this Council's watch.

Whether the Town Council will try and relocate former Town Manager Mark Garcia's pet project to a different stretch of the river — and pay REP for totally new designs and hydraulic modeling — is a question that seems, at this moment, as muddy as the San Juan River after a serious rainstorm.

Attachment 12

Fisheries Division DNR Policy & Procedure	Program: **Field Operation**	
	Chapter: **Construction Impact Assessment**	Date Approved: **4/22/2005**
	Responsible Program: **Habitat Management Unit**	
Title: **Stream Crossings (Bridges, Culverts, and Pipelines)**		Number: **02.01.007**

LEGAL REFERENCES

Michigan, acting through its Department of Natural Resources, has an obligation to preserve and protect its resources as prescribed by Article 4, § 52 of the Michigan Constitution. Fish and other aquatic organisms in the public waters of Michigan are entrusted to the State for the use and enjoyment of the public, present and future.

Part 301, Inland Lakes and Streams, of the Natural Resources and Environmental Protection Act (NREPA), 1994 PA 451, as amended.

Stream crossings over State designated Natural Rivers are also subject to the respective Natural Rivers Plan (available on the MDNR web site under Forest, Land and Waters, http://www.michigan.gov/dnr) and accompanying zoning ordinances administered by the local zoning review board, or the Michigan Department of Natural Resources, Fisheries Division. The Natural Rivers Program is established pursuant to NREPA, Part 305.

Projects which obstruct or alter navigable waters of the United States require federal review by the U.S. Army Corps of Engineers under Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403). The following projects are subject to Section 10 permit review: 10,000 cubic yards or more of wetland fill; stream enclosures of 100 feet or more; stream channelization of 500 feet or more; work in Section 10 (navigable) waters; projects which involve federal or state lands or rivers (e.g. federally designated wild and scenic rivers, federal parks, national lake shores, wildlife sanctuaries); projects that would impact federal endangered species.

For all construction related projects, refer to the following Soil Erosion and Sedimentation Control guidance documents:

- Department of Management and Budget Soil Erosion and Sedimentation Control Guidebook, February 2003 http://dnrintranet/pdfs/divisions/fish/sesc/DMB_handbook.pdf
- MDNR Soil Erosion and Sedimentation Control Procedures, July 2003 http://dnrintranet/pdfs/divisions/fish/sesc/SESCProcedure7-22-03.pdf
- MDNR Fisheries Division Process for Soil Erosion and Sedimentation Control, March 2003 and Addendum, September 2003

POLICY

The Michigan Department of Environmental Quality (MDEQ) Land and Water Management Division has regulatory authority over the construction of stream crossings. Fisheries Division will review proposed activities and provide comments and concerns to MDEQ in a timely manner.

The most important objective when considering a new, replacement, or temporary stream crossing structure is to maintain a free-flowing, natural stream channel. Fisheries, hydrology, recreation, water quality, and aesthetics can all be significantly degraded by poorly designed, constructed, or maintained stream crossings. Fisheries Division will recommend alternatives that avoid construction of new stream crossings and removal of unnecessary or abandoned crossings. Whenever possible, pipeline and utility crossings should use existing stream crossings and bore/jack or directional drill installation methods. When a new stream crossing is necessary, Fisheries Division will recommend crossings that retain or restore the natural stream bottom, such as bridges or clear-span structures, in lieu of culverts. When culverts are used, single, large capacity culverts that match the bankfull channel width are preferred over multiple culverts of lower capacity. Stream crossings should be constructed with Best Management Practices (BMPs) that minimize erosion and disturbance of the stream, wetlands, floodplains, and riparian vegetation.

EXPLANATION

Stream channels are continuously shaped by variable flow patterns, the character of the soil and sediment particles in the channel, and the adjacent vegetation. In an undisturbed stream, processes of natural erosion, sediment transport and deposition are in overall equilibrium such that the average rate of material entering the stream is equal to the average rate at which the stream transports the load downstream. When a stream is altered by a crossing, fish and other aquatic organisms are often adversely affected by sediment and other pollutants both during and after construction. For example, improperly designed, undersized or incorrectly installed stream crossings can constrict flows, leading to increased sedimentation through failure or damage to the crossing structure and adjacent banks. This is problematic because excess sand in streams has numerous deleterious effects on reproduction, food sources, and physical habitat, particularly on salmonids and other fish that spawn on stream bottoms. Specifically, excessive sediment buries valuable spawning habitat (cobble/gravel) and is drawn into fish redds (nests), smothering eggs and depleting dissolved oxygen essential for survival and growth (Peters 1965; Chapman 1988). Benthic communities are affected in a manner similar to fish and may be forced to relocate or suffocate as a result of a change in velocity or streambed condition. As a result, dramatic declines in the number of benthic macroinvertebrates can result from sediment input (Cordone and Kelly 1961; Bjornn 1975).

Poorly constructed stream crossings may also create water depths and velocities that limit or prohibit passage of aquatic organisms. For example, water flow constricted through an undersized structure will often impound water, thereby increasing upstream stage, flow velocity, and downstream turbulence. High velocity/high turbulence flows can erode the streambed below the fixed elevation of the outlet, creating a physical barrier to fish passage as the crossing structure outlet becomes perched above the stream. Other causes of partial or total barriers to upstream fish migration at stream crossings may include sediment accumulation in the crossing structure, insufficient water depth, debris collection, and ice accumulation. It is critical to ensure adequate access to various habitat types throughout the stream channel for the preservation of aquatic species diversity and productivity.

When stream crossings are constructed, replaced or repaired, their free-flowing condition should be improved, a natural stream bottom retained or restored, and principles of BMPs (Michigan Department of Natural Resources 1994) for stream crossings incorporated. Design and construction that minimizes adverse environmental effects will minimize long term maintenance and repair costs. The following considerations should be required:

- Alternatives that avoid construction of new stream crossings should be considered and eliminated before new stream crossings are installed. Pipeline and utility crossings should use existing stream crossings wherever possible and use bore/jack or directional drill installation methods.
- Unnecessary or abandoned crossings should be removed.
- Provide for adequate wildlife passage through the stream crossing structure. Bridge abutments located away from the channel often provide better clearance above the stream, preserving light penetration and passage for recreation and wildlife purposes.
- Avoid interference with existing recreational or navigational uses of the stream including, in particular, fishing and canoeing.
- BMPs should be followed to reduce the amount of surface water, chemical pollutants, and sediment entering the stream.
- Disturbance to the stream bottom, banks, and surrounding area should be kept to a minimum.
- The slope at the sides of the road should be 3:1 and mulched to reduce erosion
- New crossings should be re-vegetated to discourage travel by off road vehicles. Boulders or other large natural materials such as root wads should be used to block access to crossing corridors if natural vegetation is not effective at discouraging off road vehicle traffic.
- Crossings should provide a clear span across the natural stream at bankfull capacity to avoid encroachment upon the cross-section area of the channel.
- When culverts are used, single, large capacity culverts that match the bankfull channel width are preferred over multiple culverts of lower capacity.
- Culverts should be buried 1/6 of their height to allow for sediment transport. Smaller, lighter culverts that are placed in sand or gravel should be set up to 6" deeper to allow for culvert movement during backfilling.
- Crossings should be aligned with the natural stream channel sinuosity and slope so that relocation or straightening of the stream is not necessary.
- The structure should incorporate, retain, and re-establish as much natural stream bottom material as possible.
- If placement of a culvert causes disturbance or release of sediments, an in-stream detention basin may be required.

Kelley D. Smith
Division Chief Signature

4/22/05
Date

CITATIONS AND REFERENCES

Bjornn, T.C. 1975. Sediment affects fish, aquatic insect habitats, and fisheries resources. Focus on renewable resources, Volume 4 (1), University of Idaho Forest, Wildlife and Range Experiment Station, Moscow, Idaho.

Chapman, D. W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society 117:1-21.

Cordone, A.J., and D.E. Kelly. 1961. The influence of inorganic sediment on the aquatic life of streams. California Fish and Game 47:189-228.

Michigan Department of Natural Resources. 1994. Water Quality Management Practices on Forest Land. http://dnrintranet/pdfs/divisions/fish/HMU/WaterQualityBooklet_57739_7.pdf

Peters, J.C. 1965. The effects of stream sedimentation on trout embryo survival. Pages 275-279 *In* Biological problems in water pollution. Third Seminar, 1962. U.S. Dept. Health, Education, and Welfare, Public Health Service, 999-WP-25, 424p.

Attachment 13

Michigan Stream Team White Paper
Whitewater Parks
May 2012

This white paper addresses issues associated with the development of whitewater parks (WWPs) in Michigan rivers. WWPs commonly use artificial rock or wood structures to augment natural whitewater features (steep, fast-flowing stream reaches, usually with rocky substrates) or to create new ones. Two WWPs have recently been constructed in Michigan; one in the Bear River in Petoskey and in the Argo Dam mill race on the Huron River in Ann Arbor. Several others have been proposed around the state. The WWP's noted above, like many installed in other states, consist of channel-spanning boulder drop structures that increase water velocity in short reaches by significantly reducing channel width and cross-sectional area and increasing local channel slope to vertical or near-vertical. These WWP structures, like all man-made in-stream structures, have the potential to negatively impact stream hydrology and hydraulics, sediment transport, channel morphology, and ecology, which collectively are known as stream function.

The primary goal of any stream construction project should be to maintain or restore stream function. Stream function is defined in the Clean Water Act as the physical, chemical and biological processes that occur in ecosystems. Stream function concerns specific to WWPs include:

- Accommodation of the stream's seasonally variable hydrology without triggering geomorphic instability in the channel or interfering with other stream functions such as organism passage.
- Conveyance of the stream's sediment, organic material, and woody debris loads.
- Connectivity for fish, macroinvertebrates and other aquatic organisms.
- Loss of interstitial habitats for fish and macroinvertebrates.
- Maintenance of hyporheic exchanges.
- Disruption of riparian habitat.
- Degradation of water quality.
- River dynamics.

Brief summaries of these stream function concerns follow.

WWP structures can potentially impact stream hydrology and hydraulics in several ways. Low-flow dams/weirs incorporated into certain WWP structures reduce channel width by up to 90 percent, creating velocity barriers to organism passage and potentially increasing shear stress on the downstream stream bed and banks. Further, Rosgen (2008) identified that placement of material in the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime. Rosgen categorized blockages of 30-50% as extensive, greater than 50% as dominating or human influenced where low-head dams, velocity control structures, etc. have an influence on the existing flow regime, such that significant channel adjustments occur.

These narrow weirs can also create stagnant pools that strand aquatic organisms and raise water temperature (Kohler and Hubert 1993). Certain WWP structures can eliminate shallow water habitats important for fish spawning and predator avoidance and isolate the stream channel from the adjacent floodplain, especially when the WWP includes above-channel rock "wings," benches, terraces, or viewing platforms. Local changes in stream hydraulics can also interfere with sediment transport, organism passage, and hyporheic exchanges; see below.

Many of the channel spanning structures associated with WWPs are low head dams and have similar effects of what is thought of as more traditional low head dams (Ligon, et al. 1995; Shuman 1995; Ward and Stanford 1989). Dams interfere with sediment transport by creating sediment deposition zones in the pools between structures, which in turn may eliminate preferred fish habitat, interfere with downstream drifting of macroinvertebrates, and lower dissolved oxygen concentrations. WWP structures may also interfere with the transport of small and large organic materials. Organic material transport plays a crucial role in stream health, from fallen leaves that are food for macroinvertebrates to large woody debris that provides sediment retention in stream channels and cover for fish.

Aquatic organisms require a high degree of ecological connectivity for access to spawning habitats, genetic exchange, recruitment of new individuals from source populations, and minimization of predation due to stranding. WWPs can create passage barriers or stranding hazards for fish and other aquatic organisms due to a combination of high water velocities, inadequate water depths, high vertical drops, turbulence, and lack of interstitial spaces for resting cover.

Colorado Parks and Wildlife (CPW) is conducting ongoing studies monitoring fish passage through WWP structures. Physical measurements taken at various WWP sites suggest that these structures function as barriers to certain fish species and life stages for at least a portion of the annual hydrologic cycle. More conclusive results on the effect of WWPs on fish passage is forthcoming (Kondratieff 2012). The CPW has documented flow velocities exceeding 10 feet per second (fps) at various WWPs throughout Colorado during low flow periods. These flows are excessive and work to date has found they exclude most upstream fish passage.

This concern is further supported by studies conducted on the Truckee River in the State of Nevada by the U.S. Fish and Wildlife Service (USFWS). A condition of the permit issued for the Rock Whitewater Park on the Truckee called for fish passage, but unimpeded fish passage has not been documented to date so the structures will be modified (Cotter 2012).

Recently, the Michigan Department of Natural Resources (MDNR) measured velocities over WWP structures located in the mill race of Argo Dam, on the Huron River. Velocity measurements ranged from approximately 6 to 13 fps over the structures. Additional velocity measurements were collected independently by MDNR and USFWS at WWP structures on the Bear River in Michigan, and consistently exceeded 10 fps. Velocity measurements were taken at all sites well below bankfull discharges. These high velocities are greater than the known burst capabilities of most of the native fish species present in Michigan rivers (Bell 1986).

Many WWP installations eliminate interstitial habitats (the spaces between rocks) and hyporheic connections for macroinvertebrates and smaller fish when the structures are grouted or cemented together. Exchange of water between the stream channel and the hyporheic zone (the porous region beneath and beside a stream bed, where shallow groundwater and surface water mix), where it exists, is important to nutrient and carbon assimilation and temperature moderation, and therefore to macroinvertebrate productivity and general water quality. WWPs, especially those with structures whose rocks are held in place with grout, cement or similar materials, can interfere with or eliminate hyporheic exchange. For the reasons noted above grouting is a concern with the Nevada Department of Wildlife (NDOW) and USFWS.

The "social footprint" of WWPs is also an issue, in that modification of a channel to maximize whitewater recreation may preclude other recreational uses. Creel surveys conducted by the CPW indicated user conflict with anglers in areas where WWPs were developed in Colorado.

WWPs may include above-channel rock "wings," benches, terraces, or viewing platforms, which often displace riparian vegetation. Riparian vegetation contributes to the health of the river by providing shade, bank stabilization, allochthonous materials, large woody debris, and habitat for aquatic and terrestrial wildlife. Riparian vegetation also improves water quality by removing excess nutrients, preventing sedimentation from bank erosion, and lowering water temperature. Water quality is vital to the biological integrity of the river, and WWP structures may greatly increase the amount of rock in the stream or riparian corridor, which may increase thermal loading to the river.

Many of the concerns with WWPs noted by the Michigan Stream Team in this whitepaper are also shared with American Whitewater. *"American Whitewater's mission is to protect and restore our nation's whitewater resources and to enhance opportunities to enjoy them safely. Our members are predominantly conservation-oriented whitewater kayakers, canoeists, and rafters. Our river stewardship program focuses on restoring rivers impacted by hydropower dams, protecting free flowing rivers from environmental harm, and ensuring that river management supports sustainable river recreation" (Colburn 2012).*

Colburn notes in his paper that:

- All in-stream channel work should protect natural structure (bedrock, boulders, and native riparian vegetation) in the existing or new streambed area.

- Rivers are inherently dynamic systems and every structure placed in a stream will one day be disassembled and moved by the stream. This process should be a fundamental component of the design. Structures should be viewed as temporary, and be designed to accelerate or guide natural processes which will eventually take over. (Special note: It should be mentioned that some WWP designers claim that their structures are permanent and that they require less maintenance than natural channel design structures).

- Regardless of any special designation, rivers belong to all citizens and should be managed accordingly. Channel design elements that appear artificial can have detrimental aesthetic impacts that can last for a generation or more.

- Generally, channel designs that mimic natural streams will benefit the ecology of the stream – and they will be consistent with natural geomorphology. For example, if the design reach is in the middle of a popular Class II whitewater river, it would be appropriate to design Class II rather than Class V rapids in the reach.

Further, American Whitewater's policy on WWPs developed in May 2007 states that, "We feel that any modifications to an impaired river channel should be made with the utmost caution, care, and commitment. It is our policy that natural un-modified river channels should not be modified for the creation of whitewater parks."

In most rivers, a healthy system reflects a shifting mosaic of habitat types. Through the process of erosion, scour, deposition, migration, and avulsion, rivers must shift in order to introduce organics, deposit materials, replenish floodplains, and regenerate riparian vegetation. This process is important to the chemical and biological cycle of the river and development of the physical form of the river. The physical form that is able to transport the water, sediment and debris of the basin without severe erosion includes; access to the floodplain and a combination of river width, depth, cross-sectional area and slope with their naturally formed pool and riffle pattern (or step-pool pattern in straighter rivers).

Hardened banks are often used at bridge abutments, rock ramps and to protect infrastructure in urban areas. These hardened reaches should blend with natural, dynamically stable reaches where the channel is allowed to adjust to its flow and sediment regime. Reaches that are hardened need to be fixed permanently in place to insure structural stability to prevent undercut or blowouts from material being transported.

WWPs often use hard structures that incorporate grout, high step height over what is naturally stable, decrease cross sectional area and deflect flow into the bank which may lead to avulsion or bank erosion. Moreover, the use of grout and not designing for fixed stability results in the potential failure, resulting in large angular concrete particles that have the potential to significantly divert flows or create erosive conditions to adjacent properties. As noted previously by American Whitewater, WWP structures are designed to be temporary and not permanent structures.

Structures should not be constructed in river systems that are unstable until stability issues are addressed. Streams whose bankfull flow does not reach the floodplain are often unstable. Hardened bank stabilization structures (including energy reduction measures, flow deflection structures, slope stabilization and armoring) can cause adverse effects to stream evolution processes, riparian succession, habitat, and biological community interactions. Structures constructed in rivers for any reason must maintain the full bankfull cross sectional area of the channel so that the channel can adjust to the normal width, depth and slope patterns. Appropriate geomorphic data must be gathered and utilized to develop designs that create and/or maintain stream form and function.

Further, structures should not be constructed in rivers that are incised where bankfull flows can not reach the adjacent bankfull flats. This concentration of bankfull flow energy enhances lateral erosion and channel down-cutting. These unstable reaches can be made dynamically stable by providing new floodplains at the bankfull elevation and appropriate grade control structures that match normal stream slope and pool riffle spacing.

Although WWPs may provide other benefits, based on our review of the available research and the Michigan experience to date, WWP structures do not fully take into account stream function as defined in the Clean Water Act. Therefore, the Michigan Stream Team does not support any instream structures that do not fully address stream function and are not designed and installed with documented bankfull characteristics of width, depth, cross sectional area and slope.

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The views expressed in this working paper do not necessarily reflect the views or policy of the Michigan Stream Team member agencies.

Attachment 14

Whitewater Parks – Considerations and Case Studies.

American Whitewater -Whitewater Parks Policy Statement Developed May 2007

The Mission of American Whitewater is "to conserve and restore America's whitewater resources and to enhance opportunities to enjoy them safely." To that end, American Whitewater does not actively participate in whitewater park projects that are outside of existing river channels. The new generation of closed system pump parks are outside the scope of American Whitewaters' mission.

In channel whitewater parks are highly diverse in their potential benefits and potential impacts to rivers and their enjoyment. American Whitewater is an organization focused on protecting and restoring rivers, and therefore we have a direct interest in whitewater parks that will either significantly impact a river or that will restore significant ecological or social values to an impaired river. We feel that any modifications to an impaired river channel should be made with the utmost caution, care, and commitment. It is our policy that natural un-modified river channels should not be modified for the creation of whitewater parks. Whitewater parks exist in a complex and dynamic context of river management, and we consider proposed parks in this context on a case by case basis. The following resources present the considerations that we believe should be part of any whitewater park design and construction process. The first resource is a detailed description of the considerations, followed by a simple flow chart based on the same considerations, and lastly we offer several case studies of whitewater parks that highlight specific considerations.

Considerations in Designing and Constructing Whitewater Parks or Features

Consideration	Potential Impact	No Effect Likely	Potential Benefit
Instream flows	Diversion of water to off-channel or features that results in a loss of stream flow.	No changes to instream flow	Flow protection through securing a Recreational In Channel Diversion if in Colorado, or flow provisions from dams to meet recreational demand.
Riverbed condition	Alteration of a natural unmodified riverbed to a less natural state.	Riverbed left unchanged, or features constructed in artificial, off-channel, or heavily modified stream channel.	Changes to heavily impacted riverbeds may restore more natural and/or functional attributes to the bed and banks.
Public safety	Changes to streambed and banks create public hazards.	Changes result in no new or unusual public safety hazards.	Changes eliminate or reduce un-natural public safety hazards such as those associated with low-head dams, irrigation diversions, re-bar, and other debris.
Fish passage	Changes to the streambed reduce or eliminate upstream and/or downstream passage of fish and other aquatic species.	Changes have no effect on fish passage	Enhanced fish passage through changes to streambed and banks that creates stream complexity and associated suitable velocities, or through recreational flow provisions that benefit passage.
Pre-existing and potential recreation values	Recreational uses such as whitewater boating, calm-water boating, angling, swimming, or sightseeing are impacted or limited through park or feature construction	Pre-existing uses are not impacted, no new uses are created.	Recreational uses are enhanced through providing better public access, fish holding, whitewater features, spectator entertainment, swimming opportunities, etc. Both the number and quality of multiple uses are enhanced.
Design and constructions qualifications	Unqualified or unprofessional design or construction can lead to a failure to meet design objectives and can threaten both public use and the river's integrity.	Adequate design and construction should meet the design objectives.	Superior design and construction can meet the most social and ecological objectives, and result in the best results over the short and long term.
Education	Parks or features may present unintentional and undesirable public education on river safety and conservation	Parks or features may present no or neutral educational opportunities.	Parks or features may offer high quality educational opportunities to both paddlers and spectators on river safety, river ecology, river conservation issues, and the watershed context.
Aesthetics	Changes may result in negative – ie less natural or unnatural – aesthetic impacts.	Changes may have little or no effect on aesthetics.	Changes may significantly improve aesthetics through restoring natural appearing riverbed and banks, with a vegetated native riparian area
Operation and maintenance commitment	Lack of long term commitment may result in feature failure and associated risks to public safety and ecological integrity.	Adequate commitment should maintain project in original condition	Superior commitment may result in site changes to enhance recreational and/or ecological benefits through adaptive management.
Riparian integrity	Changes may replace a native and/or intact riparian area with non-natives or introduced rock or concrete.	Changes may have no effect on riparian area.	Changes may restore a native and intact riparian area to previously impacted sites.
River Access	Changes could limit public access for some or all river users.	Changes may have no effect on public access	Changes may enhance public access for all river users.
Permitting	Parks or features should always be built under the appropriate permits.	Parks or features should always be built under the appropriate permits.	Parks or features should always be built under the appropriate permits.
Public involvement	Changes made without public input could inadvertently and unnecessarily impact public uses or ecological values.	Adequate public input should secure public approval or understanding for design	Superior public involvement may significantly enhance the number and extent of social and ecological values a park or feature can protect, create or restore.